United States Patent [19]

Kita

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[45] **Date of Patent: Jun. 25, 1985**

[54] **ELECTRONIC WRISTWATCH WITH PRINTER FUNCTION**

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[73] Assignee: **Casio Computer Co., Ltd.**, Tokyo, Japan

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[30] **Foreign Application Priority Data**

Jul. 27, 1984 [JP] Japan 59-155380

[51] **Int. Cl.**[3] **G04B 47/00**; G04B 45/00
[52] **U.S. Cl.** **368/10**; 368/41
[58] **Field of Search** 368/10, 41, 42, 44, 368/46, 71

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,164,038	8/1979	Nachtigal	368/10
4,195,220	3/1980	Bristol et al.	368/46
4,361,874	11/1982	Yasuda	368/28
4,451,896	5/1984	Pomerlead et al.	368/10

Primary Examiner—Vit W. Miska
Attorney, Agent, or Firm—Frishauf, Holtz, Goodman and Woodward

[57] **ABSTRACT**

An electronic wristwatch with a printer has a printing head which is arranged inside a wristwatch case with a recording paper loading portion and which performs printing on the recording paper. The printing head is moved by an operation member, and a displacement thereof is detected by a detecting portion. A print control circuit controls printing of the printing head in accordance with a speed corresponding to the displacement detected by the detecting portion.

6 Claims, 28 Drawing Figures

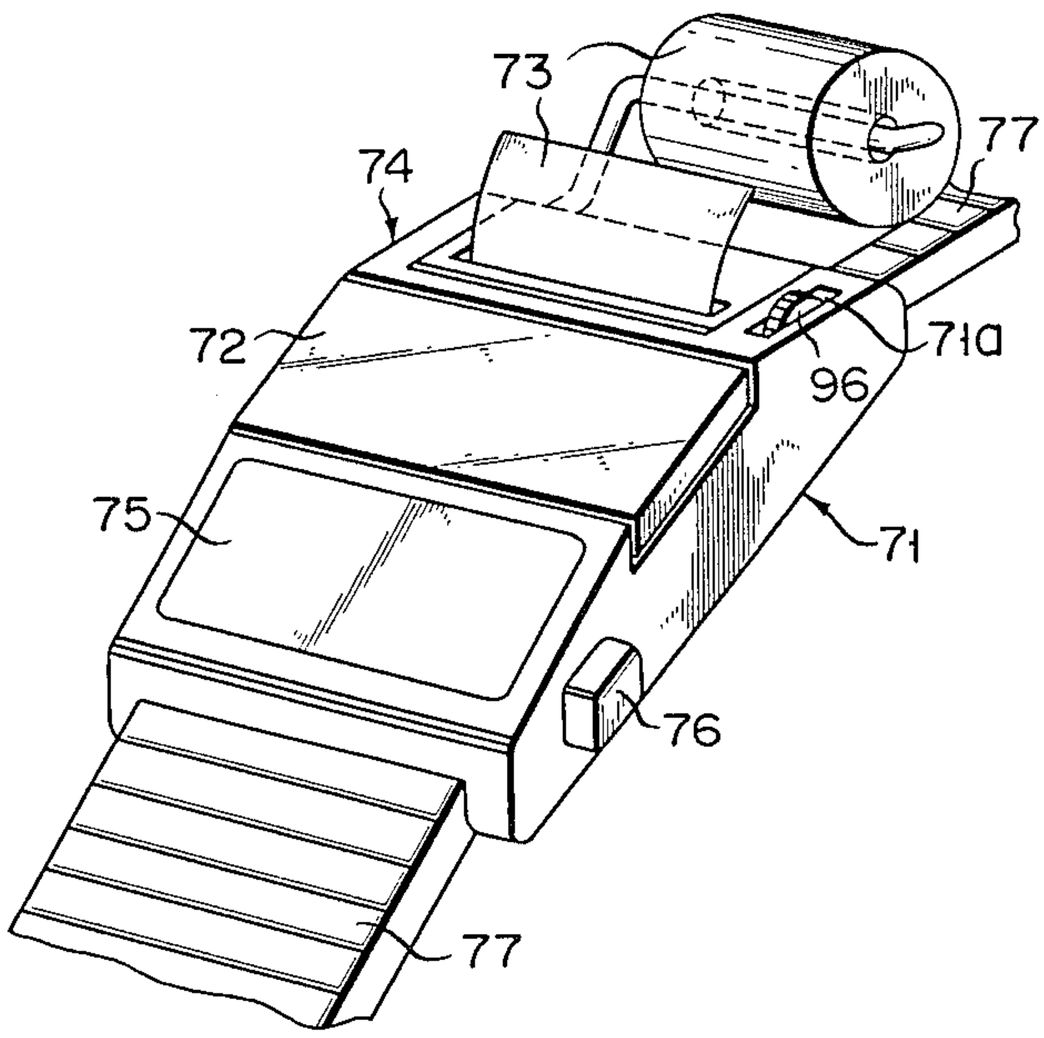


FIG. 1

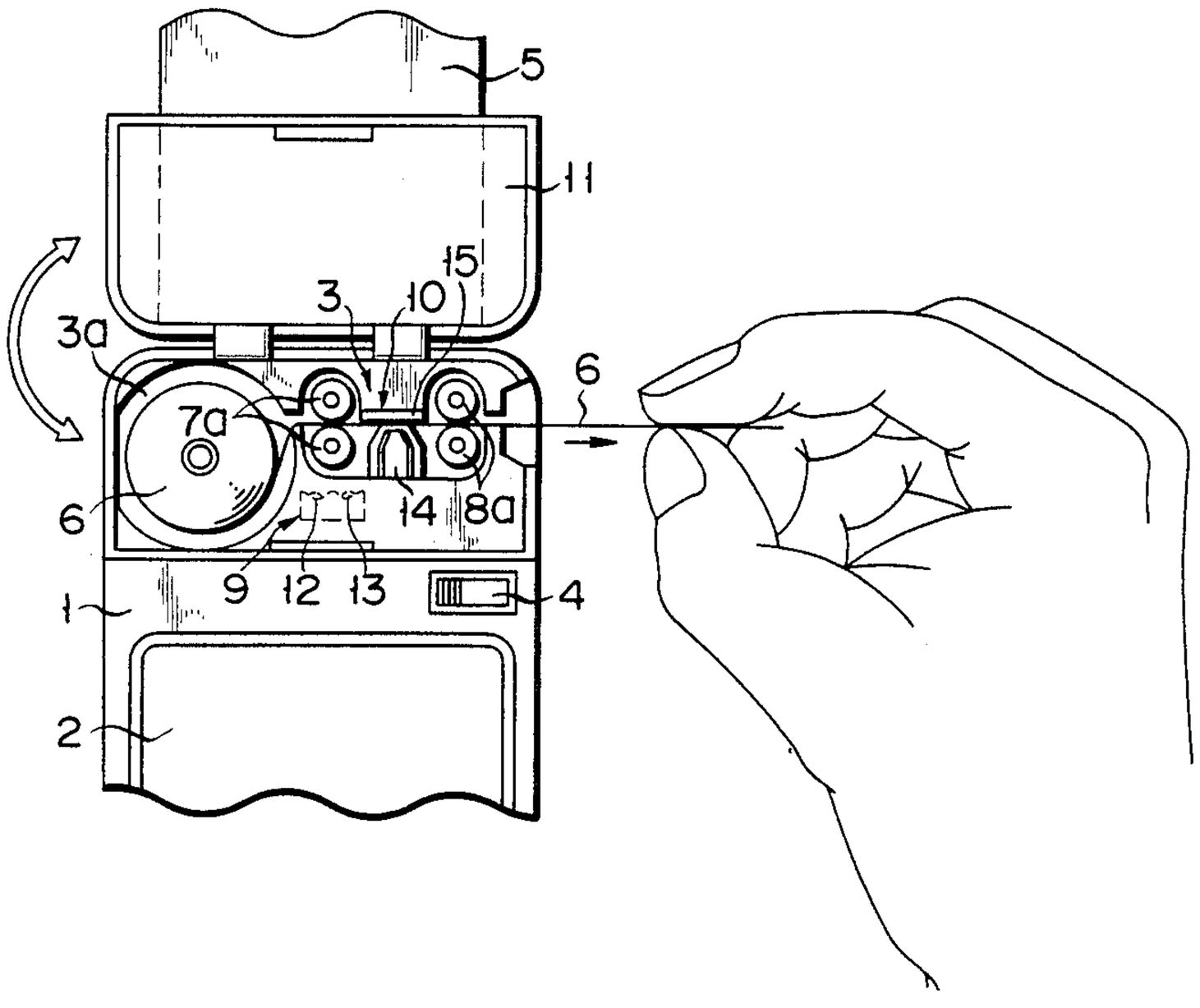
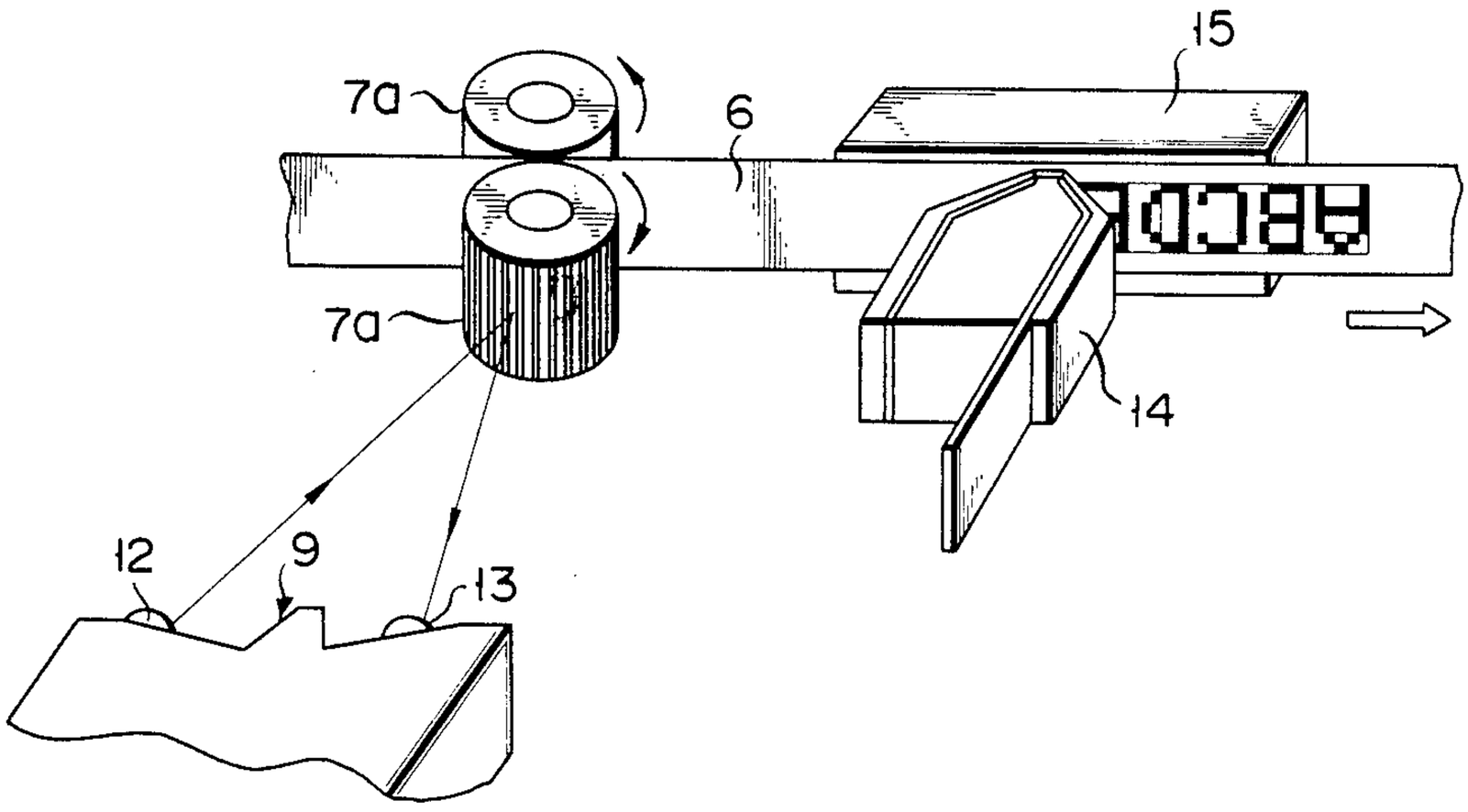


FIG. 2



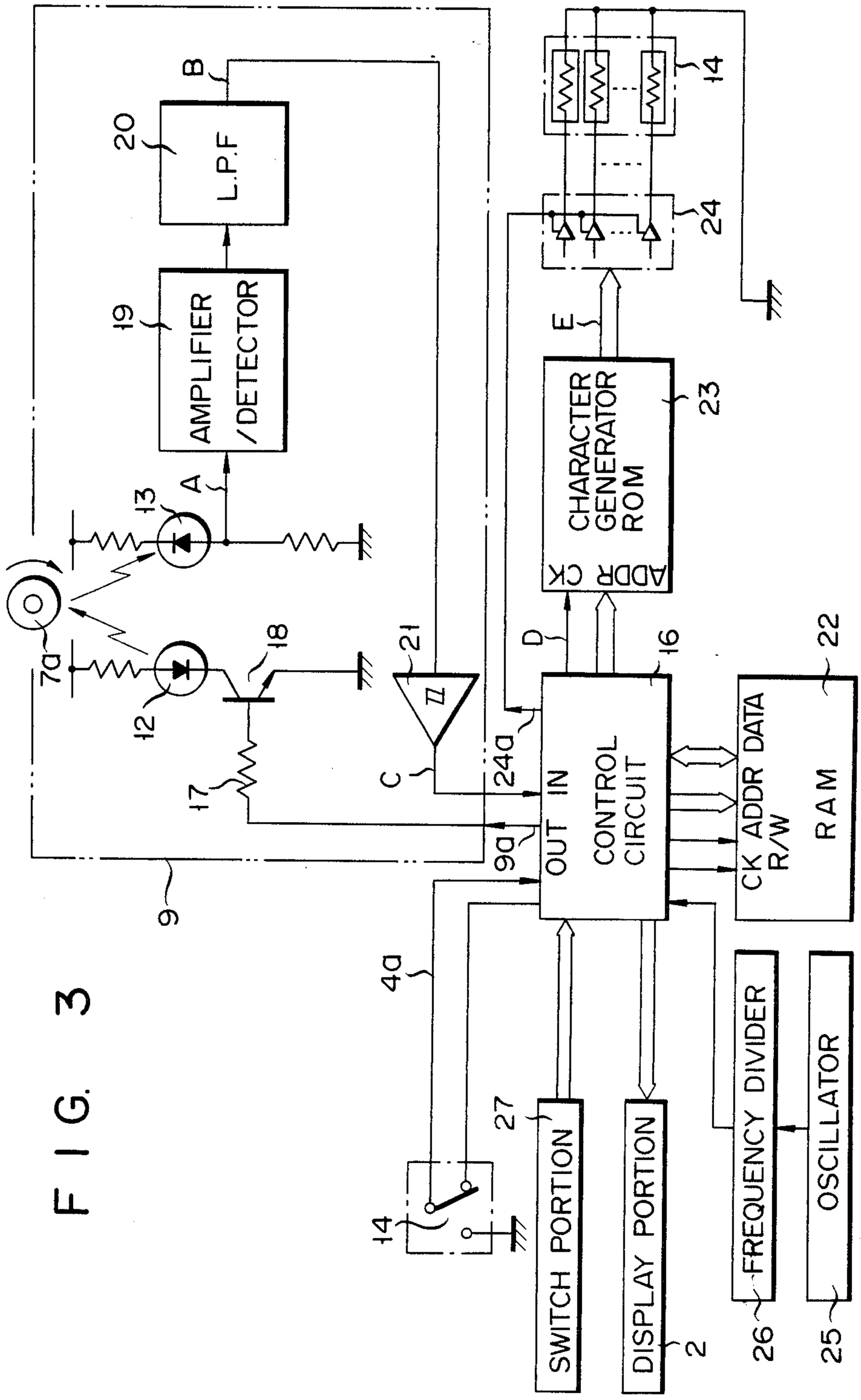

B
20
L.P.F
19
AMPLIFIER /DETECTOR
A
13
7a
12
18
17
21
C
9
9a
24a
14
24
E
CHARACTER GENERATOR ROM
ADDR CK
23
D
16
OUT IN
CONTROL CIRCUIT
CK ADDR DATA R/W
RAM
22
4a
14
27
SWITCH PORTION
DISPLAY PORTION
2
FREQUENCY DIVIDER
26
OSCILLATOR
25

FIG. 3

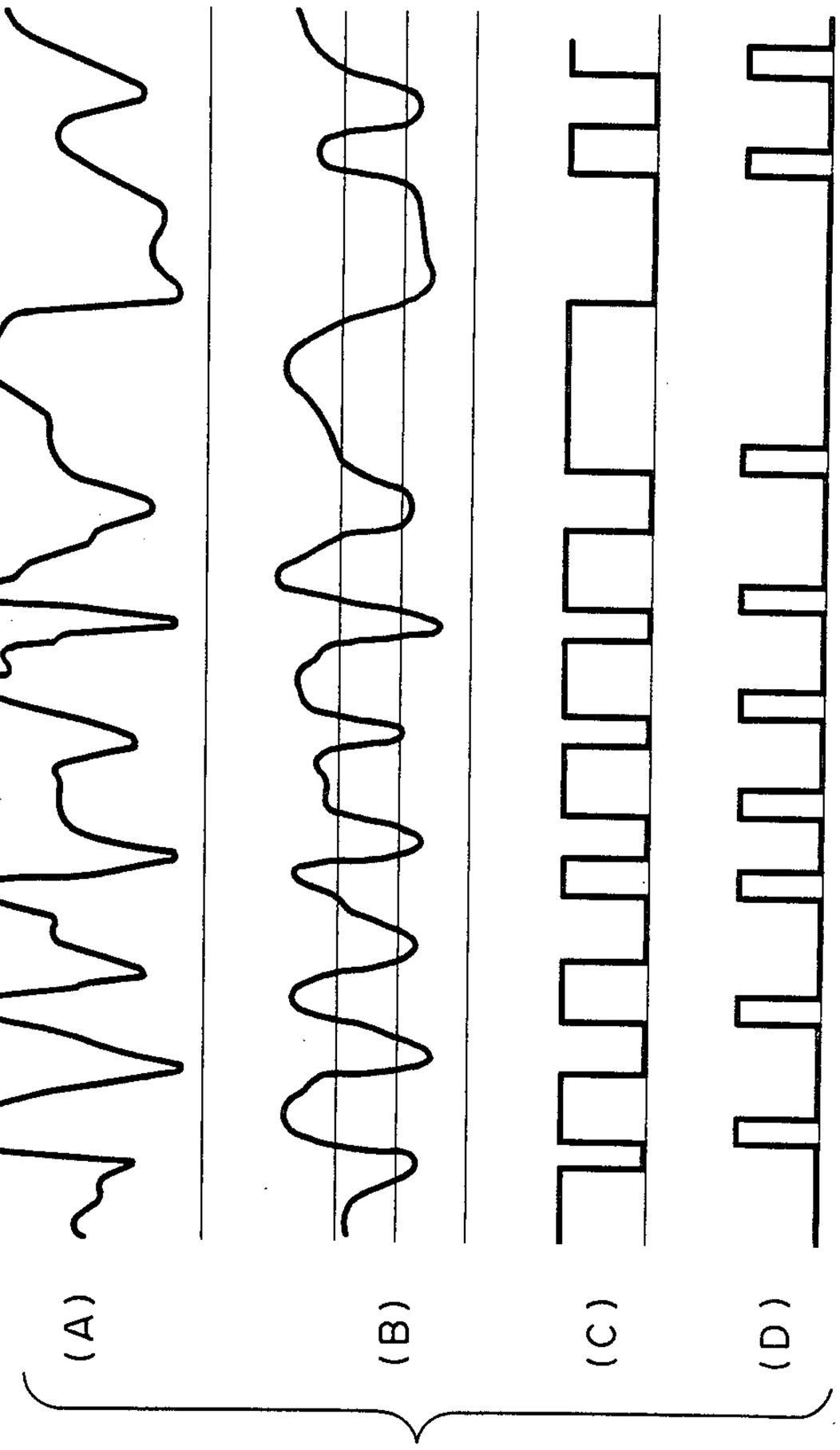


FIG. 4

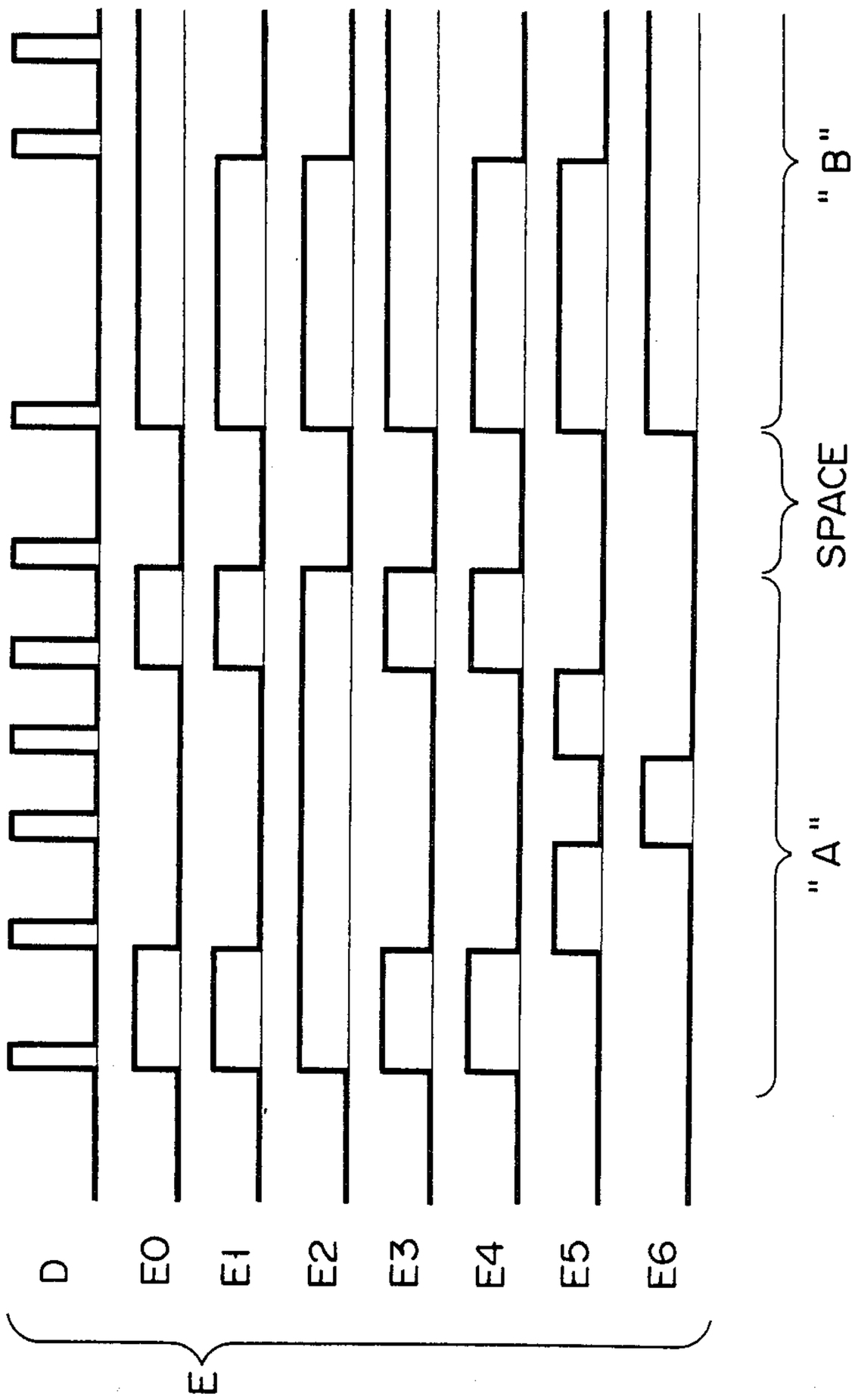


FIG. 5

FIG. 6

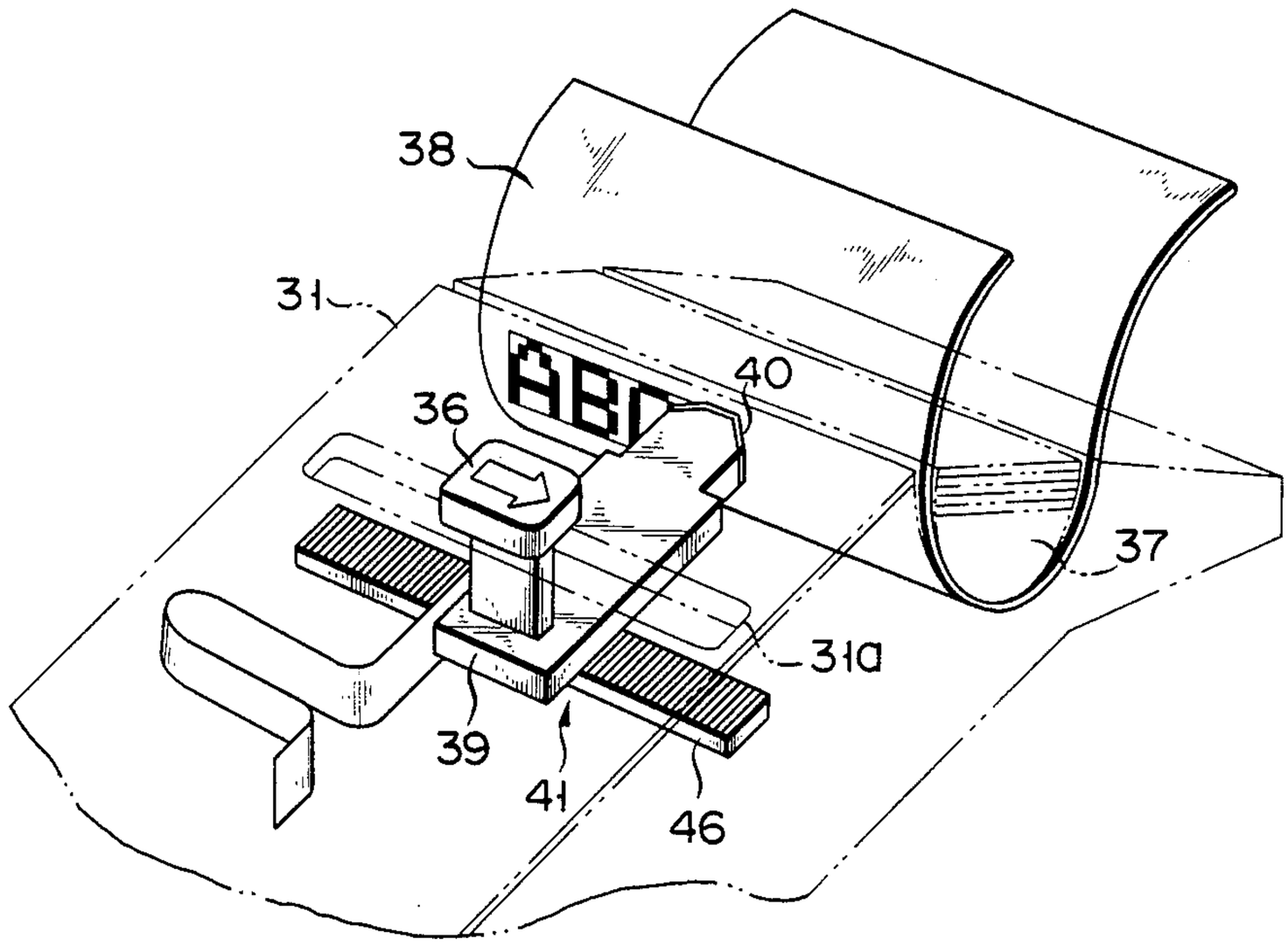


FIG. 8A

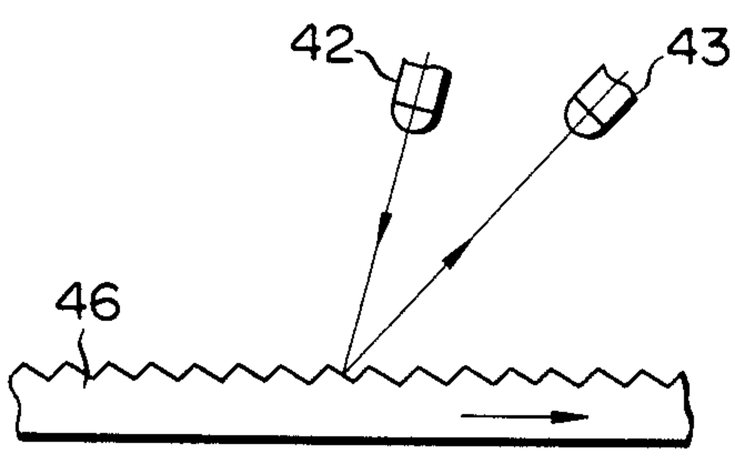


FIG. 8B

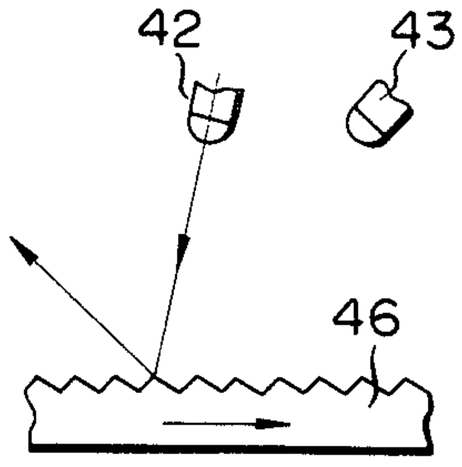
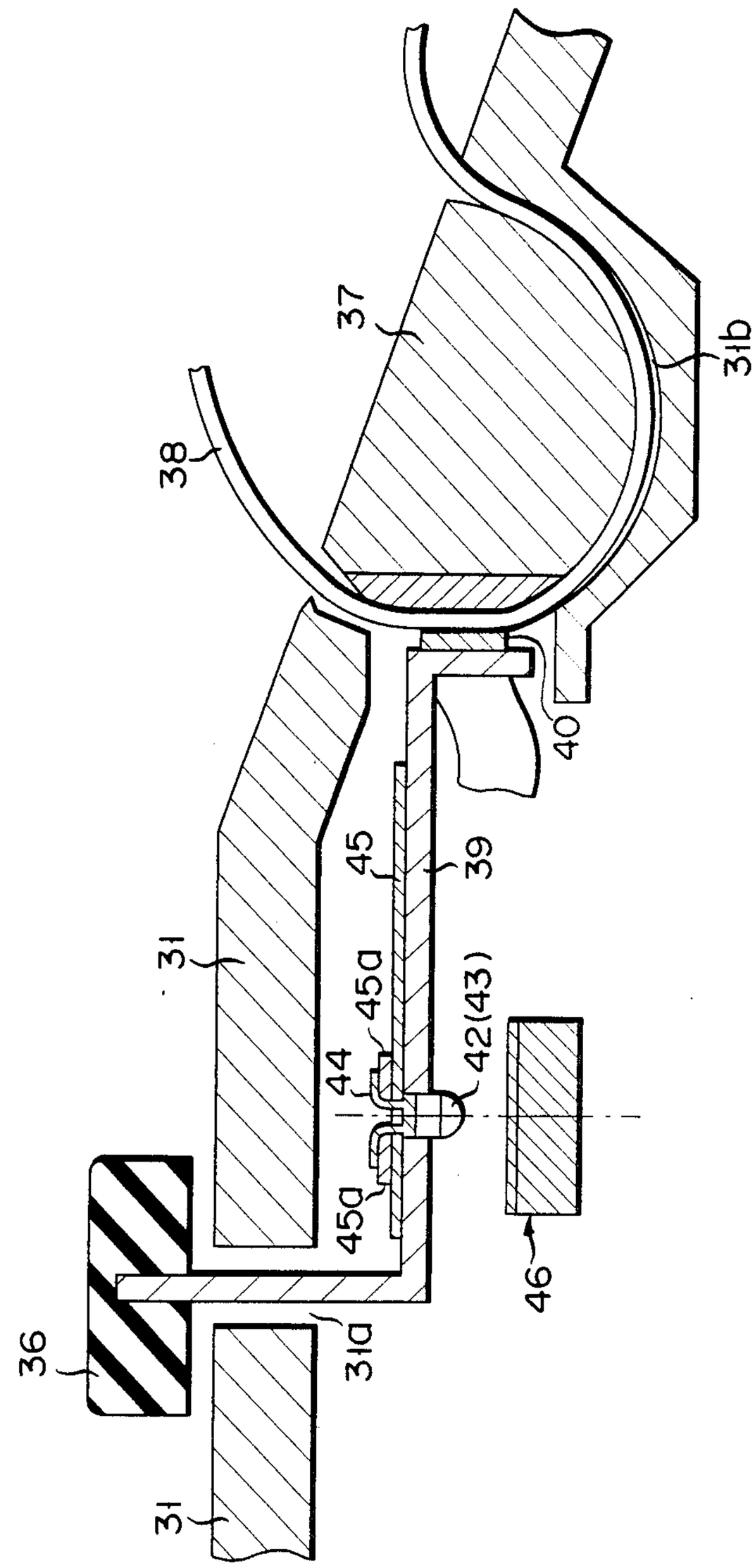


FIG. 7



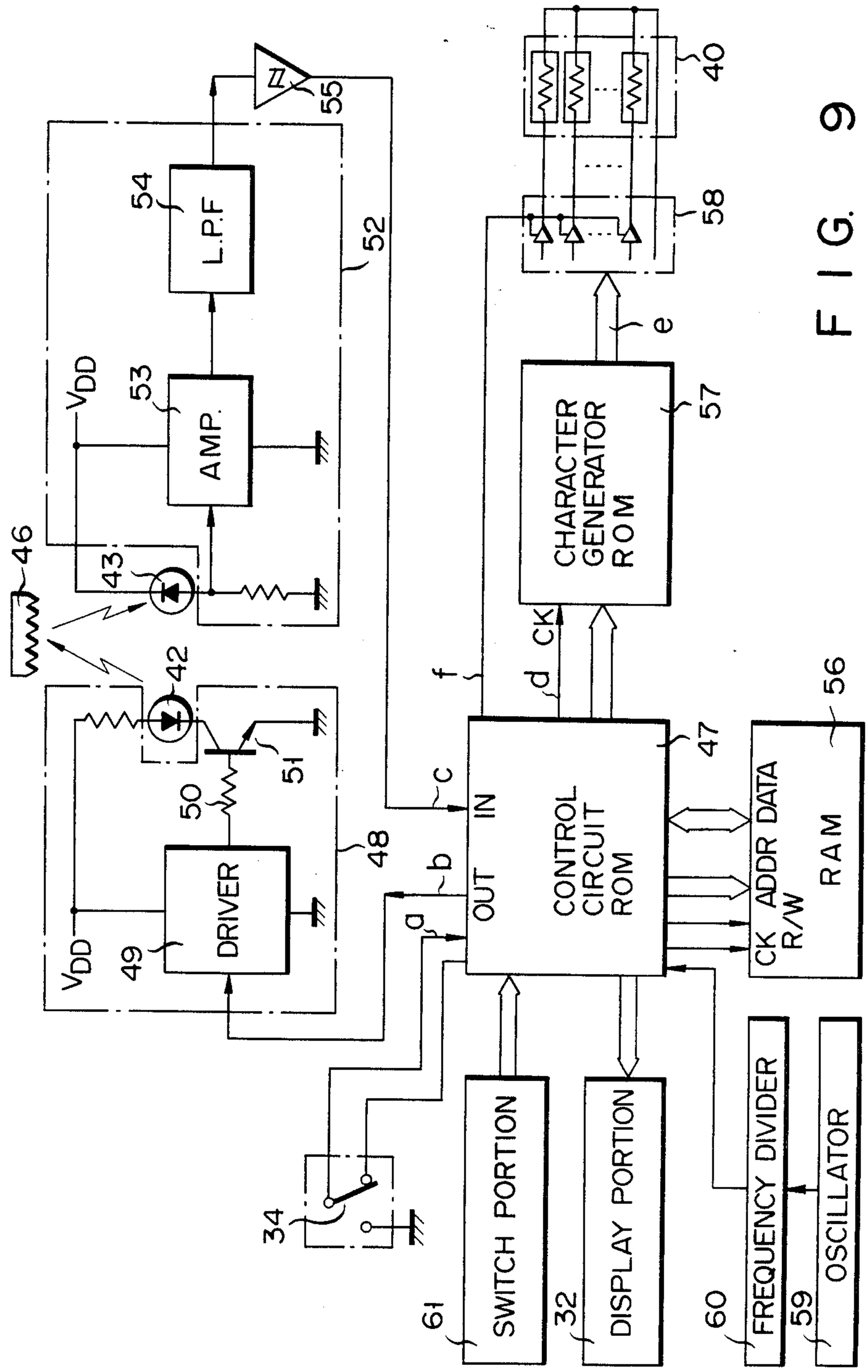

40
58
e
57
CHARACTER GENERATOR ROM
f
d CK
47
c
IN
OUT
CONTROL CIRCUIT ROM
56
CK ADDR DATA R/W
RAM
b
48
a
34
61
SWITCH PORTION
32
DISPLAY PORTION
60
FREQUENCY DIVIDER
59
OSCILLATOR
55
54
L.P.F
52
V_{DD}
53
AMP.
46
43
42
50
51
V_{DD}
49
DRIVER

FIG. 9

FIG. 10A

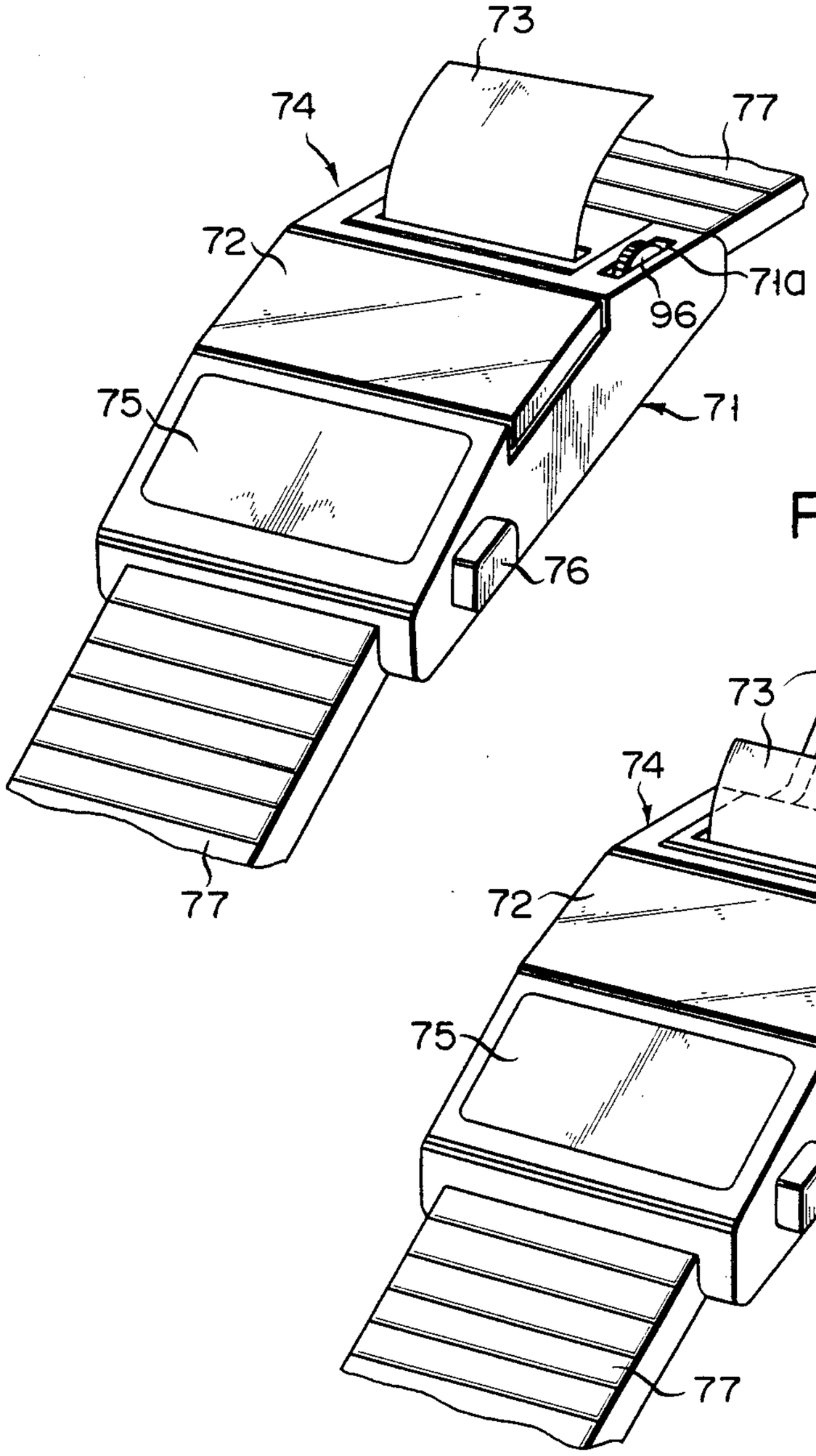


FIG. 10B

FIG. 11A

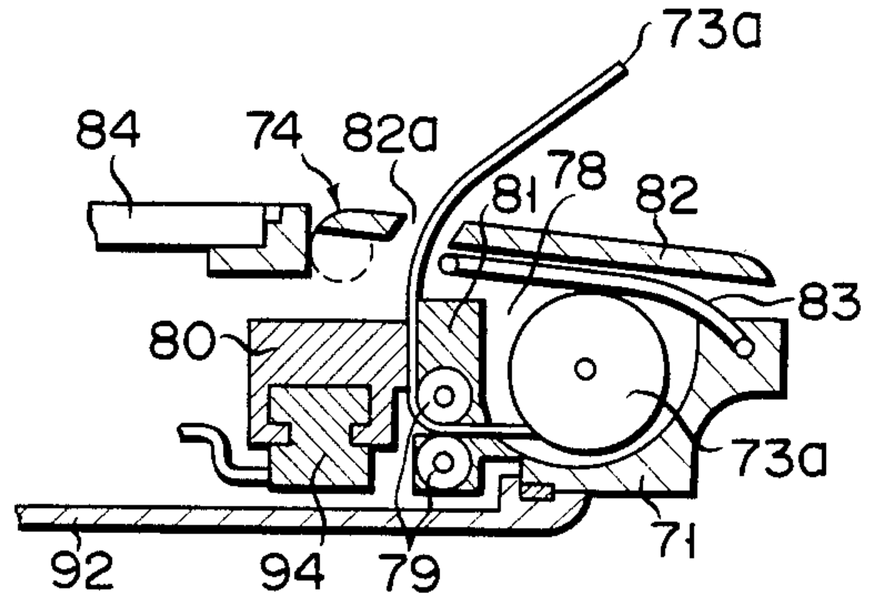
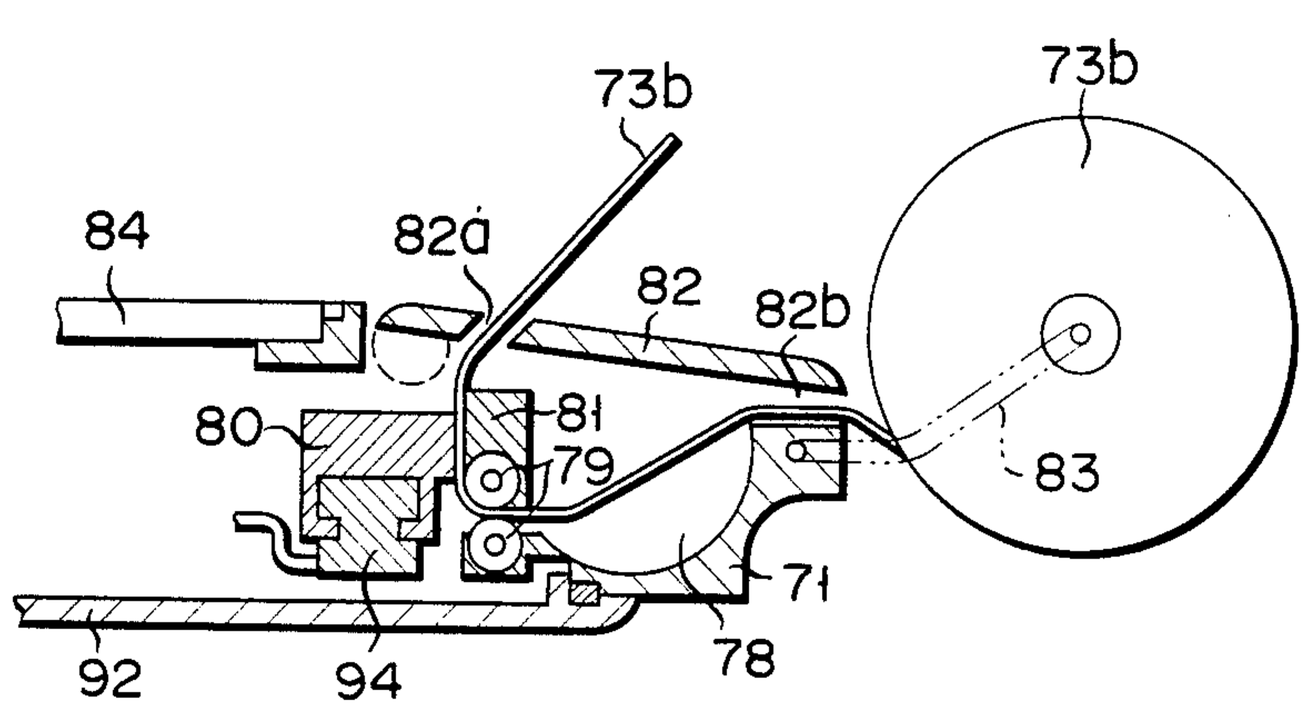
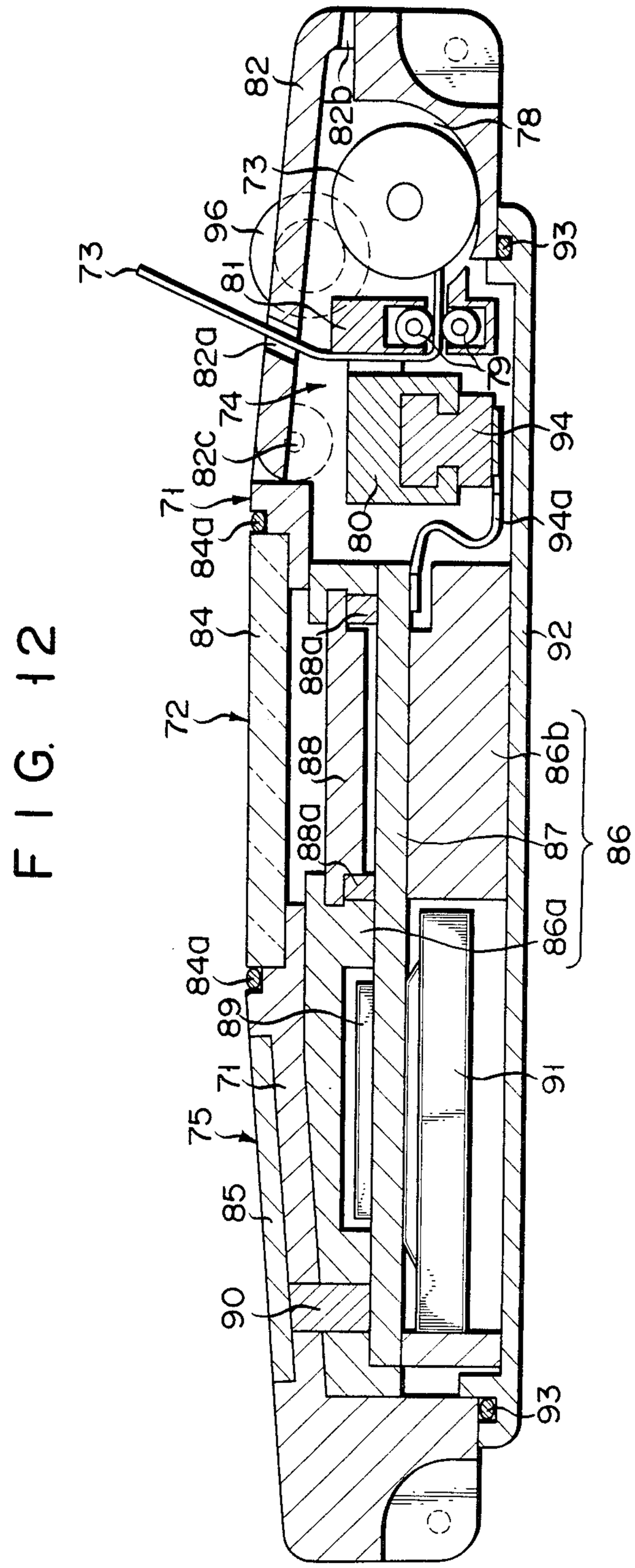


FIG. 11B

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82b
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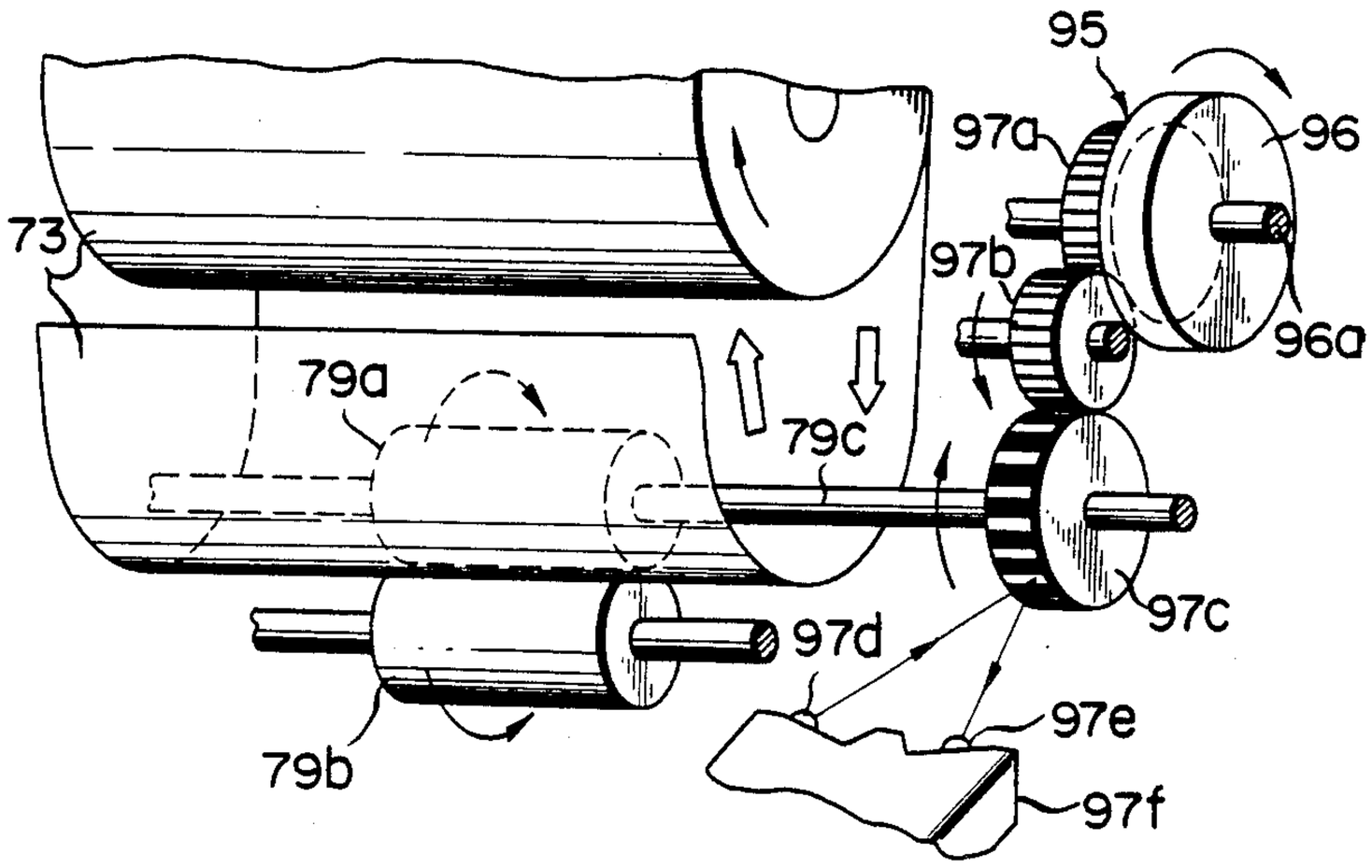
73
96
81
73
93
82a
74
76
94
82c
71
84a
80
94a
84
88a
92
72
88
86b
88a
87
86
84a
89
71
91
75
85
90
93

FIG. 12

FIG. 13


95
97a
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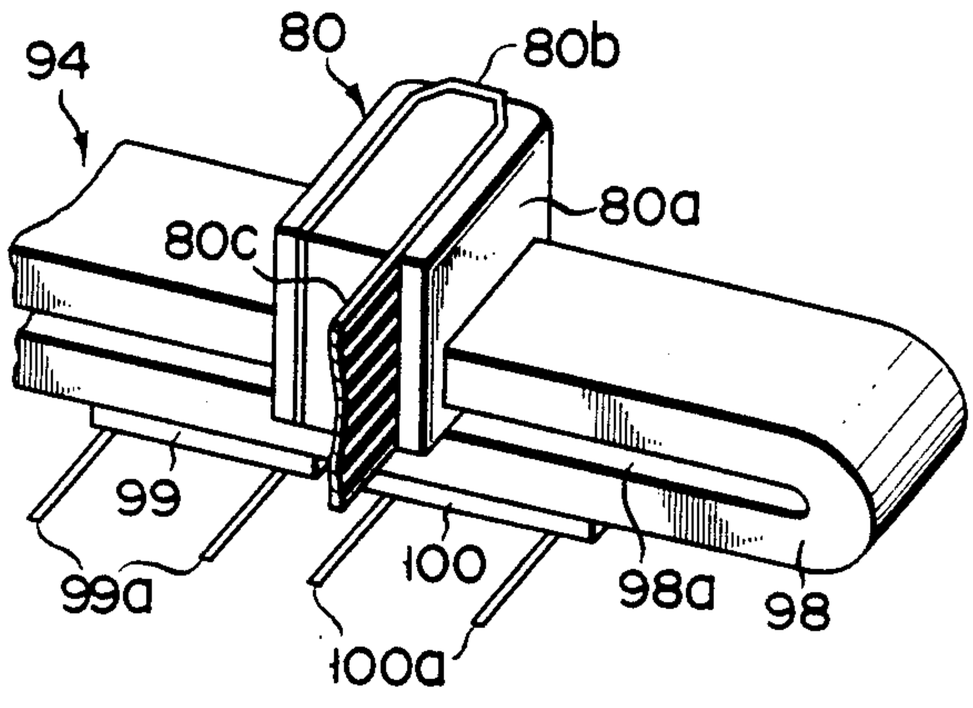
97b
96a
73
79a
79c
97c
97d
97e
97f
79b

FIG. 14


94
80
80b
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99
99a
100
100a
98a
98

FIG. 15

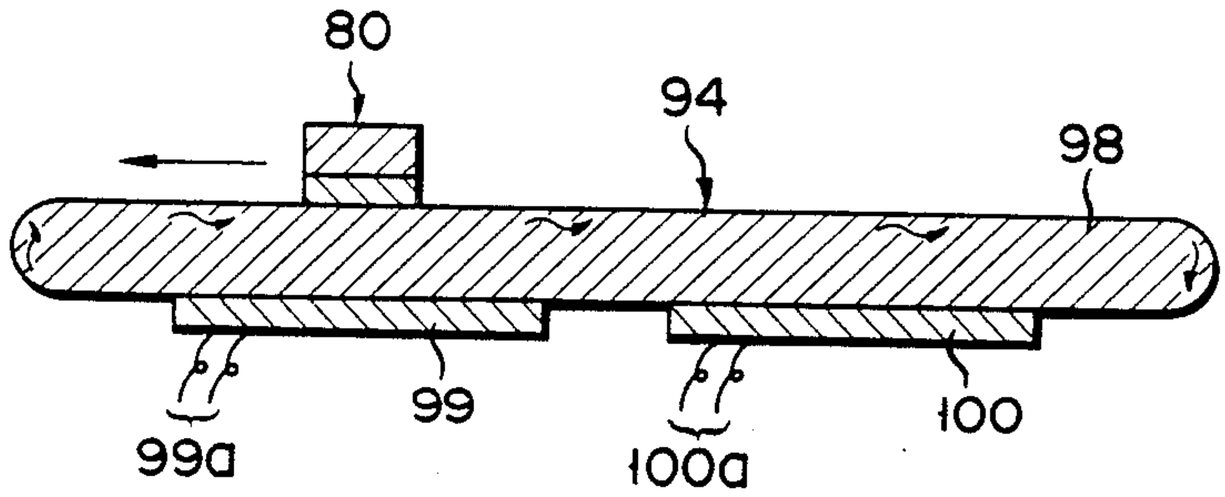
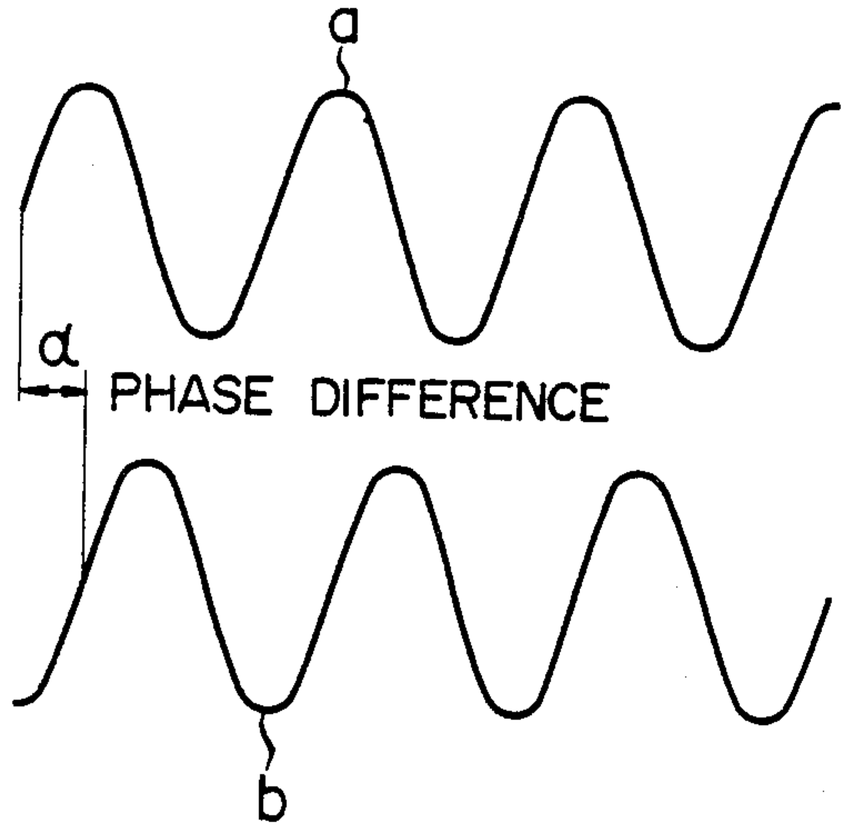


FIG. 16



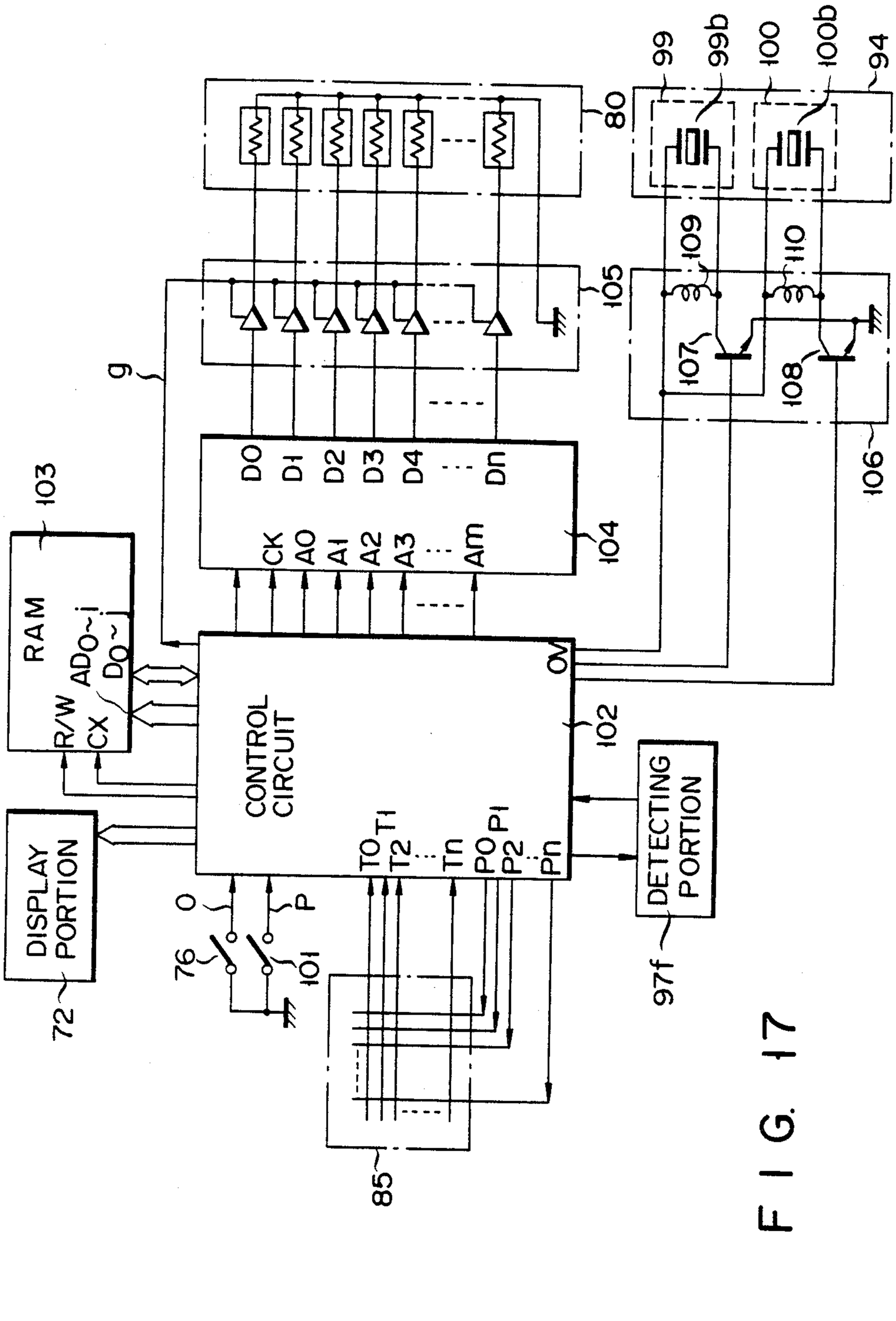

99
99b
100
100b
94
80
101
101
109
110
105
107
108
106
g
D0 D1 D2 D3 D4 ... Dn
CK A0 A1 A2 A3 ... Am
104
103
RAM
AD0~i
D0~i
R/W
CX
OV
102
CONTROL CIRCUIT
T0 T1 T2 ... Tn P0 P1 P2 ... Pn
DISPLAY PORTION
72
O
P
76
101
85
DETECTING PORTION
97f

FIG. 17

FIG. 18

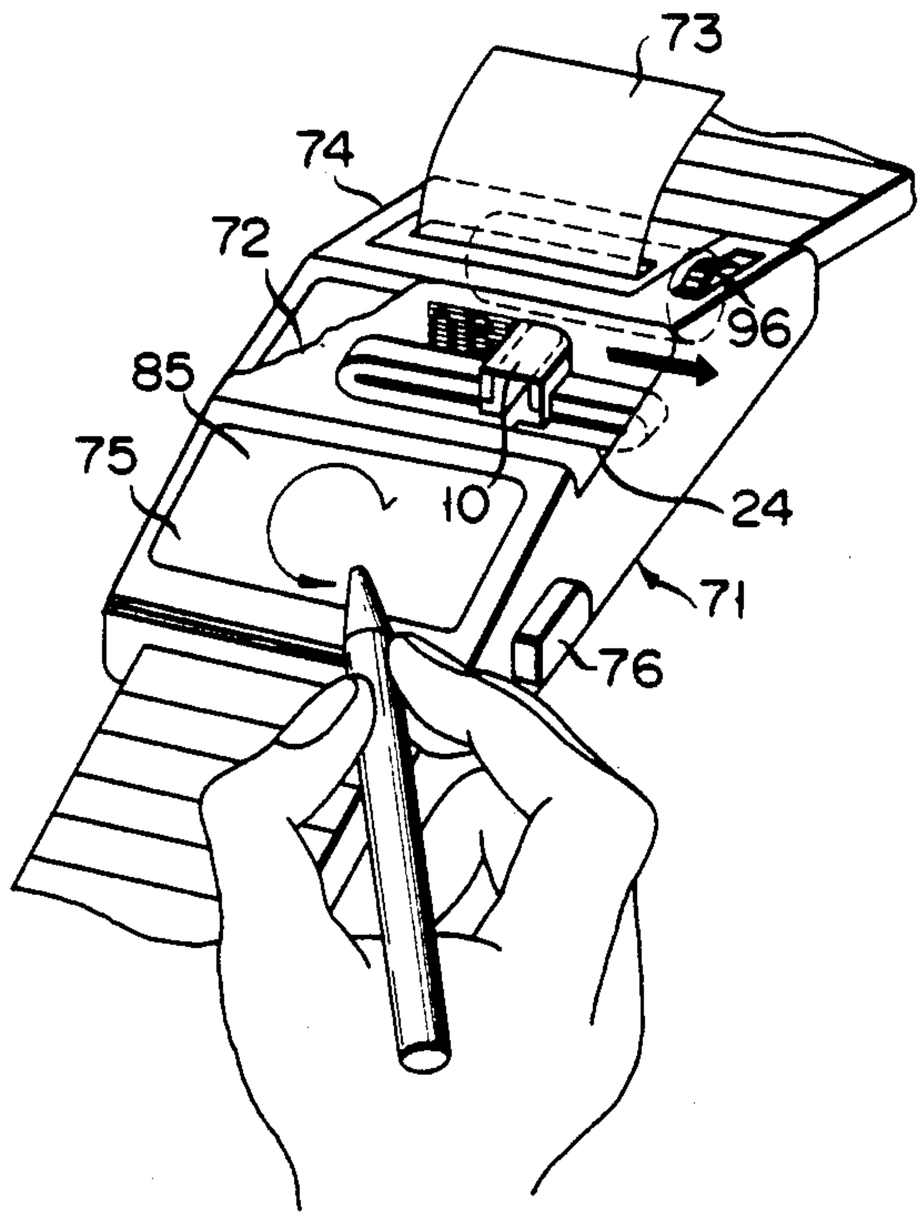


FIG. 19

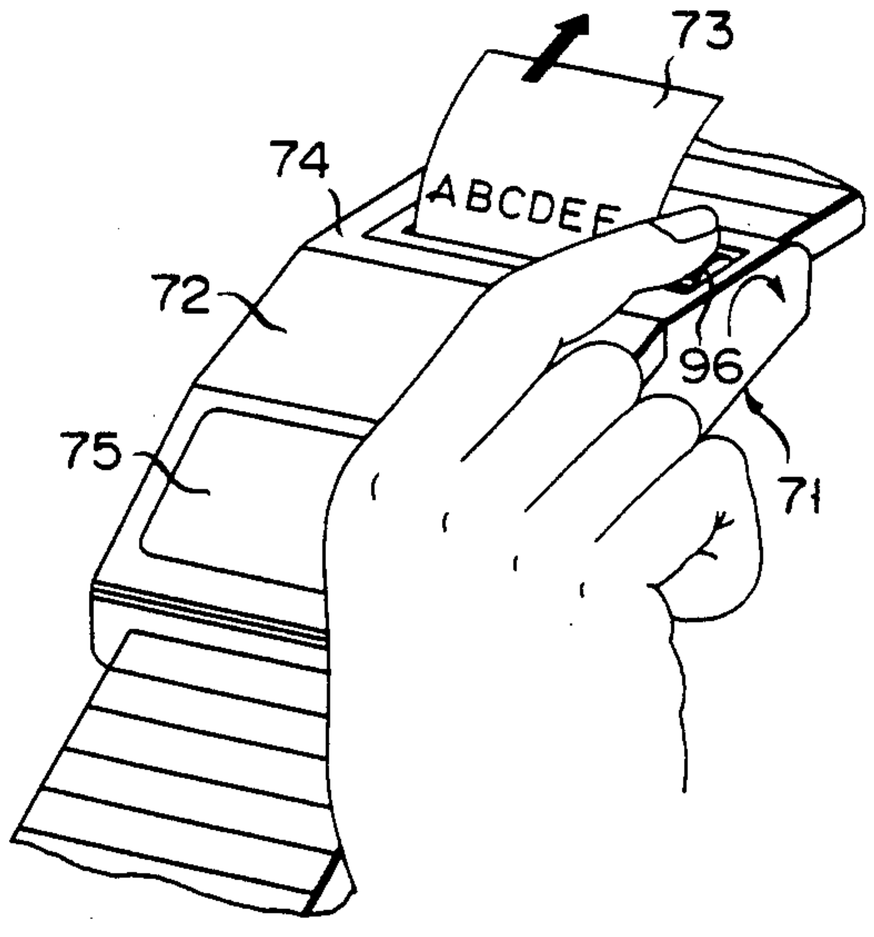


FIG. 20

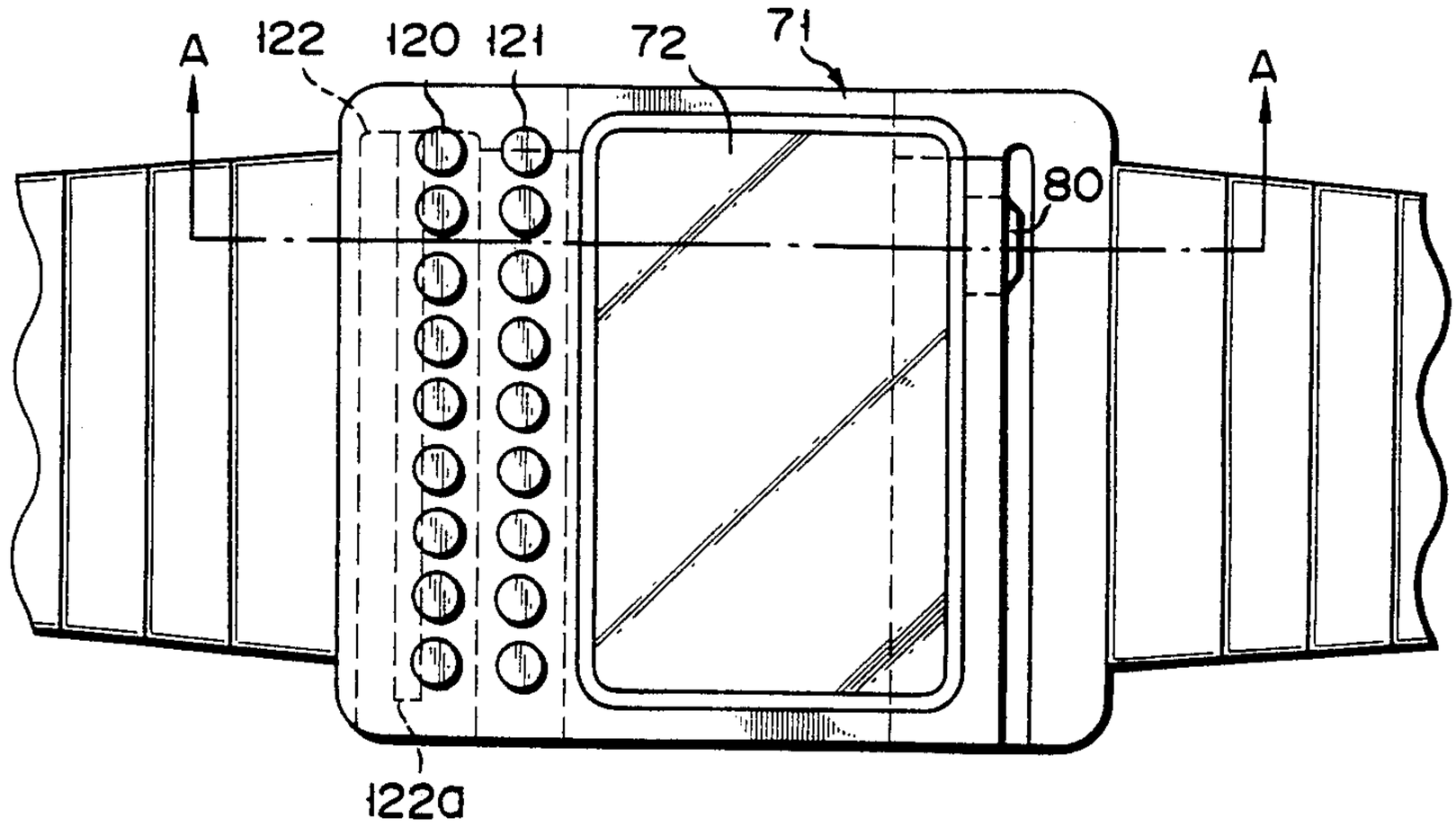


FIG. 21

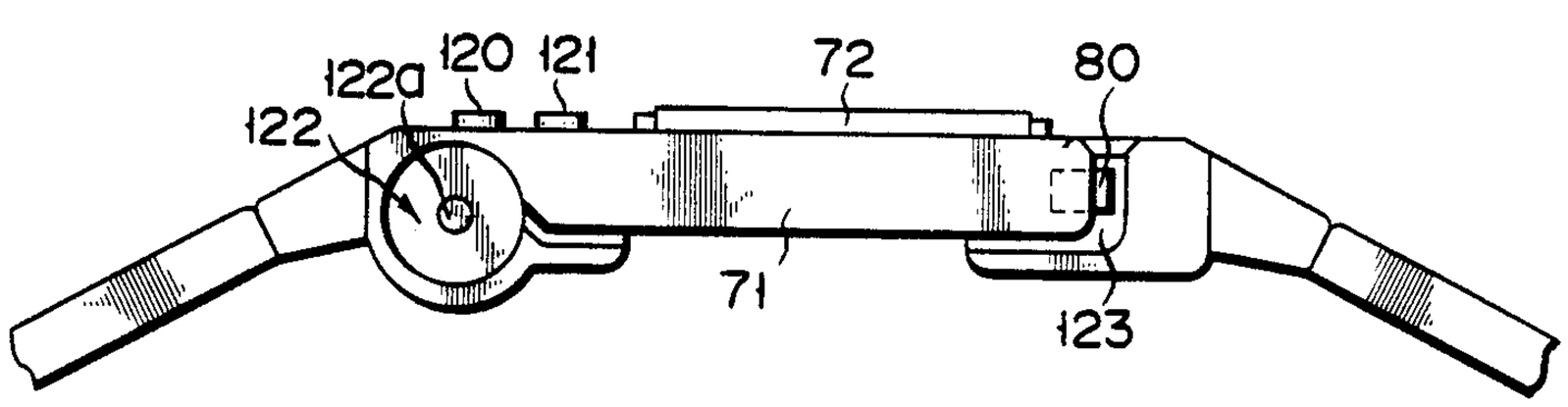
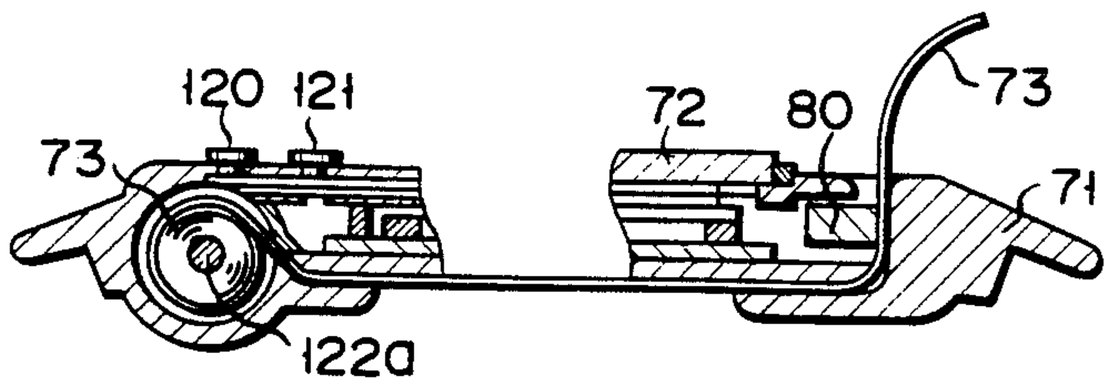


FIG. 22



ELECTRONIC WRISTWATCH WITH PRINTER FUNCTION

BACKGROUND OF THE INVENTION

The present invention relates to an electronic wristwatch with a printer function.

Electronic wristwatches display time with pointers or a digital display device and generally have other functions associated with time such as a stop watch function or a plurality of alarm functions.

Recently, electronic wristwatches have acquired other functions such as a calculation function, a schedule table preparation function, or a game function. Various information relating to those functions is displayed by an optical display device in place of the time for confirmation by a user of the wristwatch.

In an electronic wristwatch of this type, desired information can only be displayed and not recorded. In order to record such information, the user must copy it on a sheet of paper or the like.

In order to prevent this problem, the wristwatch can be provided with a printer to print desired information. However, when a printer is assembled in an electronic wristwatch, the watch inevitably becomes large and heavy, and thus become impractical.

A conventional printer uses a stepping motor or the like to move a printing head. In order to convert the rotational movement of the stepping motor into linear movement, a conversion mechanism such as a spiral bar, a belt, a wire and the like must be driven through a gear mechanism.

Printing paper must also be fed in synchronism with the movement of the printing head and the printing timing. Thus, feeding of printing paper also requires a complex gear mechanism.

When a printer is assembled in an electronic wristwatch, the wristwatch becomes large and heavy as described above. In addition, power consumption is increased, and the cell life is shortened.

SUMMARY OF THE INVENTION

The present invention has been made in consideration of this and has as its object to provide an electronic wristwatch with a printer which has low power consumption and which is simple in construction and small in size.

In order to achieve the above object of the present invention, there is provided an electronic wristwatch with a printer comprising: a wristwatch case means having a recording paper loading portion; a printing head means, arranged inside said wristwatch case, for printing on the recording paper; an operation member means, manually operated, for moving said printing head means; detecting means for detecting a displacement of said printing head which is performed by manual operation of said operation member; and printing controlling means for controlling the printing of said printing head at a speed corresponding to the displacement detected by said detecting means. In an electronic wristwatch with a printer having the above configuration, the operation of the printing head can be controlled in accordance with the amount of movement of the head upon manual operation and without requiring a motor for feeding recording paper. Therefore, the printer can be rendered compact in size. Even if this compact printer is assembled in the wristwatch case, the wristwatch need not be rendered big. The weight and the power consumption of the wristwatch can be kept low, thus increasing the cell life.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view showing the main part of an electronic wristwatch with a printer according to an embodiment of the present invention, wherein recording paper is pulled manually;

FIG. **2** is an enlarged view of the main part of a drive portion shown in FIG. **1**;

FIG. **3** is a block circuit diagram of the electronic wristwatch with a printer according to the present invention;

FIGS. **4**(A) to **4**(D) show waveforms at predetermined positions of the block circuit diagram shown in FIG. **3**;

FIG. **5** is a timing chart of character signals generated by a character generator **23** shown in FIG. **3**;

FIG. **6** is a perspective view showing the construction of the main part of a printer portion according to another embodiment of the present invention;

FIG. **7** is a longitudinal sectional view of a printer portion shown in FIG. **6**;

FIGS. **8**(A) and **8**(B) are views showing reflection of light among a light-emitting element, a reflector, and a light-receiving element;

FIG. **9** is a block circuit diagram of an electronic wristwatch with a printer according to the embodiment shown in FIG. **6**;

FIG. **10**(A) is a perspective view showing the outer appearance of an electronic wristwatch with a printer according to still another embodiment of the present invention;

FIG. **10**(B) is a perspective view showing the outer appearance of an electronic wristwatch with a printer according to still another embodiment of the present invention, wherein recording paper is supported outside a wristwatch case in the embodiment shown in FIG. **10**(A);

FIG. **11**(A) is a sectional view of a printer portion shown in FIG. **10**(A);

FIG. **11**(B) is a sectional view of a printer portion shown in FIG. **10**(B);

FIG. **12** is a sectional view showing the overall electronic wristwatch with a printer including the printer portion shown in FIG. **11**(A);

FIG. **13** is a view showing the construction of a paper feed mechanism in FIGS. **11**(A) and **11**(B);

FIG. **14** is a perspective view showing the construction of a main part of an ultrasonic motor shown in FIG. **12**;

FIG. **15** is a sectional view for explaining the operation principle of the ultrasonic motor shown in FIG. **14**;

FIG. **16** shows the waveform for explaining the operational principle shown in FIG. **15**;

FIG. **17** is a block circuit diagram showing an electronic wristwatch with a printer according to still another embodiment of the present invention;

FIG. **18** is a perspective view showing the outer appearance of the electronic wristwatch with a printer for explaining the printer function;

FIG. **19** is a perspective view showing the state wherein printed recording paper is pulled from the electronic wristwatch with a printer shown in FIG. **18**;

FIG. **20** is a plan view of the electronic wristwatch with a printer according to the present invention;

FIG. 21 is a side view of the electronic wristwatch with a printer shown in FIG. 20; and

FIG. 22 is a sectional view along the line A—A in FIG. 20.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a plan view showing a main part of an electronic wristwatch with a printer according to an embodiment of the present invention, and FIG. 2 is an enlarged perspective view of a drive portion thereof. Referring to these figures, reference numeral 1 denotes a wristwatch case. A display portion 2 for displaying information such as time, a printer 3, and a power source switch 4 for the printer 3 are arranged in the wristwatch case 1. A wristwatch band 5 is attached to the rear end of the wristwatch case 1.

When recording paper 6 is pulled outside the wristwatch case 1, the printer 3 prints one line on the paper 6 in its pulling direction in accordance with the speed at which the paper 6 is pulled. The printer 3 has a recording paper storage portion 3*a*, pairs of guide rollers 7*a* and 8*a*, a detection portion 9 for detecting pulling of the paper 6, and a printing portion 10. The top portion of the printer 3 is covered with a cover 11 to be opened or closed thereby. The storage portion 3*a* rotatably stores a roll of recording paper 6. The recording paper 6 is sandwiched between the rollers 7*a* and 8*a* which are rotated with friction when the recording paper 6 is pulled. A light-emitting elment 12 such as a light-emitting diode and a light-receiving element 13 such as a photodiode or a phototransistor in the detecting portion 9 detects the speed at which the recording paper 6 is pulled. As shown in FIG. 2, light emitted from the light-emitting element 12 is irradiated on the outer circumferential surface of one guide roller 7*a*, and light reflected from the guide roller 7*a* is received by the light-receiving element 13. Thus, the rotational speed of the roller 7*a* is detected so as to determine the pulling speed of the recording paper 6. The detecting portion 9 then produces a detection signal to be described later. In order to allow this detection operation, thin black and white stripes are axially formed by printing or etching in the outer circumferential surface of the guide roller 7*a*, as shown in FIG. 2. Changes in density of light received from the guide roller 7*a* corresponding to these black and white stripes are detected to determine the rotational speed of the guide roller 7*a*. The printing portion 10 is arranged between the pairs of guide rollers 7*a* and 8*a* and prints in accordance with the pulling speed of the recording paper 6. As shown in FIG. 2, the printing portion 10 has a printing head 14 such as a thermal printing head and a platen 15 (a paper press in the case of a thermal printer). In accordance with the detection signal from the detecting portion 9, the printing head 14 prints on the recording paper 6 passing between the printing head 14 and the platen 15.

FIG. 3 shows the circuit configuration of the electronic wristwatch with a printer described above. The power source switch 4 is for turning on the printer function and supplies an ON/OFF signal to a control circuit 16. The control circuit 16 controls the overall circuit. In response to an ON signal 4*a* from the power source switch 4, the control circuit 16 supplies from its OUT terminal a drive signal 9*a* to the detecting portion 9. The drive signal 9*a* opens the gate of a transistor 18 through a resistor 17 of the detecting portion 9 and turns on the light-emitting element 12, which irradiates the outer circumferential surface of the guide roller 7*a* with light. Light reflected from the guide roller 7*a* is received by the light-receiving element 13 of the detecting portion 9. Then, a signal having a waveform A modulated as shown in FIG. 4(A) by the black and white stripes on the outer circumferential surface of the guide roller 7*a*, i.e., the rotational speed of the guide roller 7*a*, is supplied to an amplifier/detector 19. This signal is amplified/detected by the amplifier/detector 19. The upper and lower portions of an output signal from the amplifier/detector 19 are cut off by a low-pass filter (L.P.F) 20 as shown in FIG. 4(B). An intermediate signal having a waveform B is supplied to a wave shaper 21. The wave shaper 21 produces a rectangular wave C as shown in FIG. 4(C), which is supplied to an IN terminal of the control circuit 16 as a detection signal. In response to the detection signal, the control circuit 16 supplies a clock pulse, a read-write signal, and an address signal to a RAM 22 to exchange data therewith. At the same time, the control circuit 16 supplies to a character generator ROM 23 an address signal and a clock pulse D (FIG. 4(D)) at the leading edge of the rectangular wave C shaped by the wave shaper 21. The clock pulse D has a pulse width corresponding to the rotational speed of the guide roller 7*a*, i.e., the pulling speed of the recording paper 6. When the speed is high, the pulse interval is wide, and when it is low, the pulse interval is narrow. In response to the address signal and the clock pulse D from the control circuit 16, the character generator ROM 23 prepares printing data E and supplies it to a driver 24, as shown in FIG. 3. As shown in FIG. 5, the printing data E consists of pulse signals E0 to E6, and each pulse is generated in accordance with the clock pulse D. One character is generated per 6 clock pulses D. The interval between the sixth and seventh clock pulses corresponds to a space between characters. In response to the printing data E and a drive signal 24*a* from the control circuit 16, the driver 24 supplies a drive signal corresponding to the pulse signals E0 to E6 of the printing data E to the printing head 14 to drive it. Then, the printing head 14 prints a predetermined character in accordance with a pulling speed of the recording paper 6.

Normally, a reference clock signal of a predetermined frequency generated by an oscillator 25 is supplied to a frequency driver 26, which frequency divides it. This signal is then supplied to the control circuit 16. In accordance with these frequency divided signals, when the power source switch 4 is OFF, the control circuit 16 causes the display portion 2 to display time information. However, when a predetermined signal for time correction or display switch is supplied from a switch portion 27, the control circuit 16 performs a time correction or display switch of the display portion 2.

In the electronic wristwatch with a printer as described above, the pulling speed of the recording paper 6 is detected by the detecting portion 9. The printing head 14 is controlled in accordance with a detection signal from the detecting portion 9. Thus, the printing head 14 prints in accordance with the pulling speed of the recording paper 6. Therefore, a paper feed motor required in a conventional wristwatch is not required, power consumption is low, the construction is simple, and the wristwatch is compact in size.

In the embodiment described above, the recording paper storage portion 3*a* is arranged inside the wristwatch case 1. However, the present invention is not limited to this. Thus, the recording paper 6 can also be

arranged outside the wristwatch case **1** and is pulled through the printer **3**. In this case, the wristwatch can be made even smaller.

FIGS. **6** to **8** show a printer portion according to another embodiment of the present invention. The printer portion prints predetermined information on recording paper **38** mounted in a holder **37** in accordance with an operation lever **36**. The printer portion slides an operation lever **36** so as to move a printing head **40** through a moving member **39** along the recording paper **38** mounted in the holder **37**. A moving position of the printing head **40** is detected by a detecting portion **41**. In response to a detection signal from the detecting portion **41**, printing data is supplied from a control circuit **47**, to be described later, to the printing head **40**, which prints accordingly. The moving member **39** is arranged inside the wristwatch case **31** and slides along the widthwise direction of the recording paper **38** held on the holder **37** in accordance with the operation of the operation lever **36**. The printing head **40**, the operation lever **36**, and the detecting portion **41** are arranged so as to have predetermined distances among them. The printing head **40** is a head of a thermal printer or the like; it has a vertical array of a plurality of dots (printing elements) which print one character on the recording paper **38** upon being shifted by a distance corresponding to one character along the transverse direction. The operation lever **36** extends from the rear end of the moving member **39** and then upward through a guide groove **31***a* formed in the wristwatch case **31**. When the projecting portion of the lever **36** is moved along the guide groove **31***a*, the lever **36** slides the printing head **40** along the moving member **39**. While the detecting portion **41** moves together with the moving member **39**, it detects the moving position of the printing head **40**. As shown in FIG. **7**, the detecting portion **41** has a light-emitting element **42** such as a light-emitting diode and a light-receiving element **43** such as a photodiode. The light-emitting element **42** and the light-receiving element **43** are arranged at the lower portion of the moving member **39** and contact metal electrodes **45***a* of a circuit board **45** formed on the upper surface of the moving member **39** through lead wires **44**. Light emitted from the light-emitting element **42** is reflected by a reflector **46** below the elements **42** and **43**, and the reflected light is received by the element **43**. In this case, the reflector **46** is a plate elongated along the moving direction of the light-emitting element **42** and the light-receiving element **43** and is fixed inside the wristwatch case **1**. The upper surface of the reflector **46** has a sawtooth-like surface, as shown in FIGS. **8**(A) and **8**(B). Therefore, the light-receiving element **43**, which receives light from the light-emitting element **42** through the reflector **46**, sequentially detects light which changes from the maximum to the minimum level in intensity in accordance with the teeth of the reflector **46** upon the movement of the moving member **39**. In this manner, the light-receiving element **43** detects the amount of movement (moving position) of the printing head **40**. The amount of light received from each tooth of the reflector **46** is maximum in the state shown in FIG. **8**(A) and is minimum in the state shown in FIG. **8**(B).

The holder **37** holding the recording paper **38** therein is a rod member of a semiarcuated shape having one pivotal end. The holder **37** is located inside a groove **31***b* formed in the wristwatch case **31** and holds the recording paper **38** inside the groove **31***b*.

FIG. **9** is a circuit block diagram of the electronic wristwatch with a printer shown in FIG. **6**. An ON/-OFF switch **34** switches between the timepiece mode and the printer mode. When the switch **34** is ON, the printer mode is set. A control circuit **47** controls the overall circuit. When an ON signal a is supplied from the switch **34**, the control circuit **47** supplies from its OUT terminal a drive signal b to a light-emitting element driving circuit **48**. The light-emitting element driving circuit **48** drives the light-emitting element **42**. When the drive signal b is received from the OUT terminal of the control circuit **47**, the driver **49** opens the gate of a transistor **51** through a resistor **50** and applies a predetermined voltage to the light-emitting element **42**. Light emitted from the light-emitting element **42** is then irradiated onto the reflector **46**, and the reflected light changes in intensity for each tooth of the reflector **46** as the moving member **39** and the printing head **40** are moved by the operation of the operation lever **36**. The light thus changing in intensity is received by the light-receiving element **43**. The light-receiving element **43** converts changes in the amount of light received per tooth of the reflector **46** into an electrical signal and supplies the electrical signal to a light-receiving element input amplifier **52**. The input amplifier **52** amplifies/detects the modulated waveform signal from the light-receiving element **43** by an amplifier **53**. A low-pass filter (L.P.F) **54** cuts off the upper and lower portions of the signal from the amplifier **53**, and a wave shaper **55** shapes the signal into a rectangular wave. The rectangular wave is then supplied as a detection signal c to the IN terminal of the control circuit **47**. In response to the signal c, the control circuit **47** supplies a clock pulse, a read/write signal, and an address signal to a RAM **56** to exchange data therewith. At the same time, the control circuit **47** supplies printing data stored in a RAM **56** and a clock pulse d to a character generator ROM **57**. In response to the printing data and the clock pulse d received from the control circuit **47**, the character generator ROM **57** prepares a character signal e and supplies it to a driver **58**. The printing data e is time-division dot data corresponding to each vertical dot array. The printing data is generated for each address in accordance with the clock pulse d and is sequentially supplied to the driver **58**. Each time a drive signal f is received from the control circuit **47**, the driver **58** drives each dot of the vertical array (printing elements) of the printing head **40** in accordance with the character signal e so as to print the corresponding character. In this case, the drive signal f and the clock pulse d are synchronous with the detection signal c. Therefore, when the operation lever **36** is moved quickly, the printing head **40** prints quickly, and when the operation lever **34** is moved slowly, the printing head **40** prints slowly. Characters are always printed in the same size.

An oscillator **59** supplies reference clock signals to a frequency divider **60** which normally supplies the frequency divided signals to the control cirucit **47**. When the switch **34** is in the timepiece mode, the control circuit **47** causes the display portion **32** to display time information. However, when a predetermined signal is supplied from a switch portion **61** requesting a time correction or display switch, the control circuit **47** performs the time correction or display switch of the display portion **32**. Printing data stored in the RAM **56** is supplied from the switch portion **61**. Printing data includes various data such as a telephone number or the name of a person.

In the electronic wristwatch with a printer as described above, when the operation lever **36** shown in FIG. **6** is slid along the guide groove **31***a*, the printing head **40** is moved along the recording paper **38**. At the same time, the light-emitting element **42** and the light-receiving element **43** of the detecting portion **41** are moved along the reflector **46**. The light received by the reflector **46** is intensity-modulated in accordance with each tooth of the reflector **46**, and the thus modulated, reflected light is received by the light-receiving element **43**. The moving speed of the operation lever **36** and hence the printing head **40** is detected. Printing data is then supplied to the printing head **40** through the control circuit **47** and the character generator ROM **57** in accordance with a detection signal obtained in this manner. Therefore, predetermined printing can be performed in accordance with the moving speed of the printing head **40**. A motor conventionally required for driving the printing head **40** or the recording paper **38** is not required, power consumption is decreased, the wristwatch structure is simplified, and the wristwatch can be rendered compact in size.

FIGS. **10**(A) and **10**(B) show an electronic wristwatch according to still another embodiment of the present invention. FIG. **10**(A) is a perspective view showing the outer appearance of the wristwatch wherein recording paper is housed inside a wristwatch case, and FIG. **10**(B) is a perspective view showing the outer appearance of the wristwatch wherein recording paper is supported outside the wristwatch case. The wristwatch has a printer function and the like in addition to the timepiece function. A display portion **72** for displaying information such as time information is arranged at the center of a watch case **71**. A printer portion **74** for printing on recording paper **73** is arranged at the upper side of the watch case **71**. A handwriting input portion **75** for inputting display information is arranged at the lower side of the watch case **71**. An ON/OFF switch **76** for switching between the timepiece function and the printer function is arranged at a side wall of the watch case **71**. Watch bands **77** are mounted to the front and rear walls of the watch case **71**.

FIGS. **11**(A) and **11**(B) show different mounting states of the recording paper **73**. FIG. **11**(A) is a sectional view of the printer portion **74** shown in FIG. **10**(A), and FIG. **11**(B) is a sectional view of the printer portion **74** shown in FIG. **10**(B). A recording paper storage portion **78** for storing the recording paper **73** is arranged inside the printer portion **74** shown in FIG. **11**(A). The storage portion **78** stores a roll of recording paper **73***a* having a small diameter, as shown in FIG. **11**(A). The recording paper **73***a* stored in the storage portion **78** is fed to a position between a printing head **80** and a paper press (platen) **81** by paper feed rollers **79**. After printing data is printed on the paper **73***a*, the paper **73***a* is fed out through an outlet port **82***a* of a cover **82**. Meanwhile, a roll of recording paper **73***b* of a large diameter is supported outside the watch case **71** through a support rod **83**. The recording paper **73***b* is fed into the storage portion **78** through an inlet portion **82***b* between the cover **82** and the watch case **71**. After the recording paper **73***b* is passed between the printing head **80** and the paper press **81** by the paper feed rollers **79**, it is fed out through the outlet port **82***a* of the cover **82**. In this case, the support rod **83** is pivotally mounted in the inner wall at the end of the watch case **71**. When the support rod **83** is not used, the cover **82** is opened to store only the support rod **83** inside the printer portion **74**, as indicated by the broken line in FIG. **11**(A).

FIG. **12** is a sectional view showing the overall internal configuration of the electronic wristwatch. A glass plate **84** is mounted in the upper surface of the watch case **71** through a packing **84***a* at a position corresponding to the display portion **72**. A tablet **85** is mounted at a portion corresponding to the handwriting input portion **75**. When the upper surface of the tablet **85** is activated by a finger, information of a character thus written is inputted. A module **86** is arranged at that portion inside the watch case **71** which corresponds to the glass plate **84** and the tablet **85**. A circuit board **87** is arranged between an upper housing **86***a* and a lower housing **86***b* of the module **86**. A liquid crystal display device **88** is connected on the upper surface of the circuit board **87** through interconnectors **88***a*. An electronic part **89** such as an LSI is also arranged on the upper surface of the circuit board **87**. An interconnector **90** is arranged at the leftmost end of the upper surface of the circuit board **87**. The liquid crystal display device **88** displays information such as time and corresponds to the glass plate **84**. The interconnector **90** electrically connects the circuit board **87** and the tablet **85** and extends from the upper surface of the circuit board **87** to be in contact with the lower surface of the tablet **85** through the upper housing **86***a* and the watch case **71**. A battery **91** is arranged below the lower surface of the circuit board **87**. A rear cover **92** is mounted on the lower portion of the watch case **71** through a water-impermeable ring **93**.

The printer portion **74** is arranged to the right of the watch case **71**. As described above, the printer portion **74** has the storage portion **78**, the paper feed rollers **79**, the printing head **80**, the paper press **81**, and an ultrasonic motor **94**, which are all arranged inside the watch case **71**. The cover **82** is mounted at the upper portion of the watch case **71**. The storage portion **78** stores the recording paper **73** and is arranged at the right side inside the watch case **71**. The paper feed rollers **79** are manually driven through a paper feed mechanism **95**, as shown in FIG. **13**, and feed the recording paper **73** stored inside the storage portion **78** to the position between the printing head **80** and the paper press **81**. The paper feed rollers **79** are vertically opposed to each other inside the storage portion **78**. The printing head **80** prints on the recording paper **73** in accordance with printing data and is mounted on the ultrasonic motor **94**. The paper press **81** presses the recording paper **73** to the printing head **80**. For this purpose, the paper press **81** is arranged above the paper feed rollers **79** and opposes the printing head **80**. As will be described later, the ultrasonic motor **94** moves the printing head **80** in accordance with an input drive signal. The ultrasonic motor **94** is arranged in opposition to the paper feed rollers **79** and is connected to the circuit board **87** through a lead wire **94***a*. The cover **82** covers the upper portion of the printer portion **74** so as to be able to open or close and is pivotally mounted on the upper portion of the watch case **71** through a hinge **82***c*. In this case, the cover **82** has the outlet port **82***a* for feeding the printed recorded paper **73** upward and the inlet port **82***b* for receiving the recording paper **73** inside the case **71**. An opening **71***a* is formed in that portion of the watch case **71** which is near the cover **82** so as to receive an operation member **96** of the paper feed mechansm **95**, as shown in FIGS. **10**(A) and **10**(B).

FIG. **13** shows the configuration of the paper feed mechanism **95**. When the operation member **96** is manu-

ally operated, the paper feed mechanism **95** rotates the paper feed rollers **79** through a gear train **97** so as to feed the recording paper **73**. The operation member **96** is a disc mounted on a rotating shaft **96***a* and partially projects upward through an opening **71***a* of the watch case **71**, as shown in FIG. **10**. The gear train **97** consists of a gear **97***a* mounted on the rotating shaft **96***a* of the operation member **96** for rotation therewith, an intermediate gear **97***b* meshing and rotating with the gear **97***a*, and a driven gear **97***c* meshing and rotating with the intermediate gear **97***b*. The driven gear **97***c* is mounted on a shaft **79***c* of the upper paper feed roller **79***a*. Therefore, when the operation member **96** is rotated by fingers, the gears **97***a*, **97***b* and **97***c* of the gear train **97** are rotated to rotate the upper paper feed roller **79***a*. When the upper paper feed roller **79***a* is rotated, the lower paper feed roller **79***b* in contact therewith is also rotated. Thus, the recording paper **73** is sandwiched between the upper and lower paper feed rollers **79***a* and **79***b* to be fed thereby.

Black and white stripes are alternately formed on the outer circumferential surface of the gear **97***c*. The rotation of the gear **97***c* is detected by a detecting portion **97***f* having a light-emitting element **97***d* and a light-receiving element **97***e*. The detection signal is processed by an electronic circuit to be described later.

FIGS. **14** to **16** show the construction of the ultrasonic motor **94**. FIG. **14** is a perspective view showing the outer appearance of the motor, FIG. **15** shows the operation principle, and FIG. **16** shows the waveform. The ultrasonic motor **94** moves the printing head **80** utilizing the vibration of a piezoelectric element. As shown in FIG. **14**, the ultrasonic motor **94** comprises a guide rail **98** for movably supporting the printing head **80** and two piezoelectric elements **99** and **100** arranged on the lower surface of the guide rail **98**. In this case, the printing head **80** comprises a head support **80***a*, a head portion **80***b* such as a thermal head arranged at the distal end of the head support **80***a*, and a wiring **80***c* for supplying printing data to the head portion **80***b*. The lower end portion of the head support **80***a* is mounted at the upper portion of the guide rail **98**. More particularly, the lower end portion of the head support **80***a* is fitted in mounting grooves **98***a* formed in two side walls of the guide rail **98**. When a predetermined voltage is applied to the piezoelectric elements **99** and **100**, they vibrate. Lead terminals **99***a* and **100***a* of the piezoelectric elements **99** and **100** are connected to the circuit board **87** through the lead wire **94***a* as shown in FIG. **12**. In this case, the voltage waveforms a and b of the voltages applied to the piezoelectric elements **99** and **100** have a phase difference α. Therefore, the piezoelectric elements **99** and **100** vibrate in different phases. In this manner, when the piezoelectric elements **99** and **100** vibrate in the different phases, the printing head **80** is moved along the guide rail **98** due to the vibration phase difference, as shown in FIG. **15**.

FIG. **17** is a block diagram showing the circuit arrangement of the electronic wristwatch described above. The ON/OFF switch **76** switches between a timepiece function and a printer function. A switch **101** corrects the time. The ON/OFF switch **76** and the switch **101** supply ON/OFF signals o and f to a control circuit **102**. The control circuit **102** controls the overall operation of the circuit. When the ON/OFF switch **76** is kept off, the control circuit **102** supplies time data to the display portion **72** and causes the display portion **72** to display the normal time. When the switch **101** is turned on, the time displayed on the display portion **72** is corrected. Furthermore, when the ON/OFF switch **76** is turned on, the control circuit **102** supplies pulse signals P0 to Pn to the tablet **85** in the handwriting input portion **75**. When a character or the like is drawn on the tablet **85**, corresponding input data T0 to Tn are supplied to the control circuit **102**. When the input data T0 to Tn are supplied from the tablet **85** to the control circuit **102**, the control circuit **102** detects one handwritten character and supplies a read/write signal, a clock pulse and an address signal to a RAM **103** to exchange data therewith. The control circuit **102** supplies a select signal e, a clock pulse f and printing data A0 to Am to a character generator **104**. The character generator **104** generates printing character signals D0 to Dn in response to the select signal e, the clock pulse f and the printing data A0 to Am. The printing character signals D0 to Dn are supplied to a driver **105**. The printing character signals D0 to Dn are time-division dot data and are produced in units of addresses in accordance with the clock pulse f. The driver **105** drives the corresponding dots of the printing head **80** in accordance with the printing character signals D0 to Dn every time it receives a drive signal g from the control circuit **102**, thereby printing a character. Drive signals h and i are supplied through a driver **106** from the control circuit **102** to the ultrasonic motor **94** for moving the printing head **80**. The drive signals h and i have a phase difference α in the same manner as in FIG. **16**. The drive signals h and i enable the gates of transistors **107** and **108** of the driver **106**, respectively. Each of the drive signals is supplied to one terminal of the corresponding piezoelectric element **99** or **100**. In this case, the other terminal of each of the piezoelectric elements **99** and **100** is connected to the ground (0 V) terminal of the control circuit **102**. Coils **109** and **110** are connected in parallel with the piezoelectric elements **99** and **100** in the driver **106**. Therefore, when the drive signals h and i are supplied to the piezoelectric elements **99** and **100**, respectively, the piezoelectric elements **99** and **100** vibrate in different phases by means of capacitors **99***b* and **100***b* and the coils **109** and **110**, respectively. The ultrasonic motor **94** moves the printing head **80**. When one character is printed, the printing head **80** is stopped. When the next character is entered by handwriting, the printing head **80** is moved again. The clock pulse f and the drive signal g are synchronized with the drive signals h and i. The printing head **80** is moved every time one character is handwritten. When the operation member **96** is manually rotated to feed out the recording paper **73**, feeding of paper is detected by the detecting portion **97***f*, and the detection signal is supplied from the detecting portion **97***f* to the control circuit **102**.

A case will be described with reference to FIGS. **18** and **19**, wherein the electronic wristwatch is used in the printer mode.

In this case, the ON/OFF switch **76** arranged on the side wall of the watch case **71** is depressed to set the wristwatch in the printer mode. In this state, as shown in FIG. **18**, when a character is manually drawn on the tablet **85** of the handwriting input portion **75**, the drawn character is entered as input data T0 to Tn to the control circuit **102**. The control circuit **102** detects that the character is entered by handwriting and supplies the printing data A0 to Am to the printing head **80**. The control circuit **102** also supplies the drive signals h and i to the ultrasonic motor **94**. The printing head **80** is moved by the ultrasonic motor **94** to print the character

written on the tablet **85**. This character is printed on the recording paper **73**.

In this manner, when one-line characters are sequentially printed on the recording paper **73** and the operation member **96** slightly extending upward from the cover **82**, as shown in FIG. **19**, is turned manually, the recording paper **73** is fed out through the paper feed rollers **79**. At the same time, a signal is supplied from the detecting portion **97***f* to the control circuit **102**. As a result, the printing head **80** is returned to the initial position and is ready for the next printing.

When the electronic wristwatch is used in the timepiece mode, the ON/OFF switch **76** is depressed and is turned off, and then the normal time is displayed on the display portion **72**.

According to the electronic wristwatch with a printer of the present invention, the control circuit **102** detects when one handwritten character is entered. In this manner, when one character is written quickly, printing can be performed quickly.

Furthermore, since the printing head **80** is directly moved by the ultrasonic motor **94** by using the piezoelectric elements **99** and **100** in accordance with the drive signals h and i from the control circuit **102**, a converting mechanism need not be used unlike the case of the conventional apparatus. As a result, the electronic wristwatch according to the present invention has a simple, compact construction. Furthermore, the recording paper **73** can be housed in the recording paper storage portion **78** in the watch case **71** or can be set on the support rod **83** arranged outside the watch case **71**. The size of the recording paper **73** is not therefore limited to the watch size, but can be extended to any length.

FIGS. **20** to **22** are respectively a plan view, a side view, and a partial sectional view showing an electronic wristwatch with a printer according to another embodiment of the present invention. A keyboard having ten keys **120** and alphanumeric keys **121** is used in place of the handwriting tablet of the electronic wristwatch in FIG. **10**. Recording paper **73** is housed in a recording paper storage portion **122** of a case **71** formed below the keyboard. A support rod **122***a* is arranged in the storage portion **122** to rotate the recording paper therearound. The recording paper **73** passes by the lower surface of the case and is subjected to printing by a printing head **80** at an opening **123** through which the recording sheet passes. The printing paper is then fed out onto the upper surface of the case **71**. Other arrangements in this embodiment are the same as those in FIG. **10**.

With this construction, the recording paper can be easily removed/loaded. Furthermore, the printer is constituted by effectively utilizing the upper and lower portions of the watch case, thereby providing a compact wristwatch.

In the respective embodiments described above, the data to be printed is not described in detail. However, current time data obtained by a timepiece circuit, alarm time data, stop watch time data, and numeric and character data (e.g., telephone numbers, addresses and names) entered at the tablet **85** or the keyboard can be directly or temporarily stored in the RAM and can be accessed at any time.

What is claimed is:

1. An electronic wristwatch with a printer comprising:

a wristwatch case means having a recording paper loading portion;

a printing head means, arranged inside said wristwatch case, for printing on the recording paper;

an operation member means, manually operated, for moving said printing head means;

detecting means for detecting a displacement of said printing head which is performed by manual operation of said operation member; and

print controlling means for controlling the printing of said printing head at a speed corresponding to the displacement detected by said detecting means.

2. An electronic wristwatch according to claim **1**, wherein said detecting means comprises optical detecting means.

3. An electronic wristwatch with a printer comprising:

a wristwatch case means having a recording paper loading portion;

a printing head means, arranged inside said wristwatch case, for printing on recording paper;

detecting means for detecting a displacement of the recording paper manually fed out; and

print controlling means for controlling the printing of said printing head at a speed corresponding to the displacement detected by said detecting means.

4. An electronic wristwatch according to claim **3**, wherein said detecting means comprises optical detecting means.

5. An electronic wristwatch with a printer comprising:

a wristwatch case means having a recording paper loading portion;

a printing head means, arranged inside said wristwatch case, for performing printing on recording paper;

input means for entering character data to be printed;

detecting means for detecting an input speed of the character data entered from said input means; and

print controlling means for controlling printing of said printing head at a speed corresponding to the displacement detected by said detecting means.

6. An electronic wristwatch according to claim **5**, wherein said input means comprises handwriting input means, and said detecting means comprises means for detecting that one handwritten character is entered.

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